Entwicklung und Wirksamkeit einer Multikomponenten-Trainingsintervention zur Förderung motorischer und kognitiver Funktionen und des psychosozialen Wohlbefindens für nicht gehfähige BewohnerInnen in der stationären Altenpflege

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Zusammenfassung

Hintergrund

Der Zustand von pflegebedürftigen BewohnerInnen der stationären Altenpflege ist gekennzeichnet durch Multimorbidität, Gebrechlichkeit und ein hohes Risiko für den Verlust von Selbstständigkeit bei Aktivitäten des täglichen Lebens (ADL). Ohne körperliches Training sind die BewohnerInnen einem stetigen Abbau motorischer Ressourcen wie Handkraft, Gleichgewicht und Mobilität ausgesetzt. Der Verlust dieser motorischen Ressourcen steht zudem in Zusammenhang mit einem reduzierten Wohlbefinden und einer reduzierten Lebensqualität und einem Abbau kognitiver Funktionen. Daher haben wirksame Trainingsmaßnahmen zur Stärkung der Gesundheitsressourcen und zur Vorbeugung oder Verzögerung von Behinderungen bei älteren institutionalisierten Menschen eine hohe gesundheitspolitische Priorität. Die meisten Studien zu Trainingsinterventionen zielen jedoch auf die Förderung von noch gehfähigen BewohnerInnen ab. Da ein großer Teil der AltenpflegeheimbewohnerInnen dieses motorische Einschlusskriterium der Studien für die Teilnahme an den Trainingsinterventionen oft nicht erfüllt, entsteht eine konzeptionelle Lücke in der Gesundheitsforschung. Studien, die die Durchführbarkeit und die Wirksamkeit eines Trainingsprogramms für nicht gehfähige BewohnerInnen adressieren, fehlen bislang. Chair-based exercise (CBE) Interventionen stellen eine Möglichkeit dar, um ein Training auch für ältere Menschen mit Mobilitätseinschränkungen möglich zu machen und somit funktionelle motorische und kognitive Ressourcen bedarfsgerecht zu fördern. Die Studienqualität von Untersuchungen zu CBE Interventionen ist jedoch oft gering und es gibt keine konkrete Anleitung für die praktische Umsetzung im Setting Altenpflege. Zudem fehlt eine adäquate Auseinandersetzung mit trainingswissenschaftlichen Prinzipien und Belastungsnormativen.

Ziel dieser Dissertation war die Entwicklung, Überprüfung der Machbarkeit und Wirksamkeit einer Trainingsintervention zur Förderung motorischer und kognitiver Funktionen und des psychosozialen Wohlbefindens für nicht gehfähige BewohnerInnen in der stationären Altenpflege.

Methoden

Zu Beginn des Forschungsvorhabens stand zunächst die Entwicklung der Trainingsintervention im Vordergrund. Dafür wurden Anhand von fünf qualitativen Interviews die Bedürfnisse und Ressourcen der BewohnerInnen einer Altenpflegeeinrichtung in Hamburg erhoben. Auf Basis von Empfehlungen eines Expertengremiums für ein Training mit Pflegebedürftigen, trainingswissenschaftlicher Prinzipien und den Ergebnissen aus den Interviews wurden zwei Multikom-

ponenten-Trainingsprogramme, eins für die gehfähigen und ein CBE Multikomponenten-Training für die nicht gehfähigen BewohnerInnen in der stationären Altenpflege entwickelt (Publikation 1). Parallel zur Entwicklung der Intervention führte der Autor eine systematische Übersichtsarbeit zu CBE in der Altenpflege durch, um den aktuellen Forschungsstand zu Interventionen, die gezielt Nichtgehfähige BewohnerInnen ansprechen, zu erheben (Publikation 2). Zur Überprüfung der Machbarkeit, Wirksamkeit und Akzeptanz sowie der Evaluation des entwickelten Trainingsprogramms für gehfähige BewohnerInnen diente eine Machbarkeitsstudie mit *N=24* BewohnerInnen im Setting Altenpflege (Publikation 3). Auf Basis der Ergebnisse aus der Übersichtsarbeit und der Machbarkeitsstudie wurde das Trainingsprogramm für die Nichtgehfähigen modifiziert und weiterentwickelt. Das modifizierte Programm wurde im Rahmen einer weiteren Machbarkeitsstudie im Prä-Post Design mit *N=7* nicht gehfähigen BewohnerInnen in einer Altenpflegeeinrichtung durchgeführt und Veränderungen in der Alltagsfunktionalität untersucht (Publikation 4). Im Anschluss folgte eine randomisierte, kontrollierte Wirksamkeitsanalyse des Trainingsprogramms (Publikation 5). Hierbei wurden die Motorik, Kognition und das psychosoziale Wohlbefinden von *N*=52 nicht gehfähigen BewohnerInnen aus vier Altenpflegeeinrichtungen in Bremen und Chemnitz vor und nach 16 Wochen Training untersucht.

Ergebnisse

Das untersuchte CBE Multikomponenten-Trainingsprogramm verbesserte erfolgreich die motorischen (Handkraft, Feinmotorik, Selbstständigkeit, Gleichgewicht) und kognitiven (kognitiver Status, Arbeitsgedächtnis) Funktionen und stabilisierte die psychosozialen Ressourcen (Wohlbefinden, Lebenszufriedenheit, Depressionsgrad) von nicht gehfähigen BewohnerInnen, während sich die Kontrollgruppe im Verlauf der 16 Wochen ohne Training in allen untersuchten Parametern signifikant verschlechterte. Trainingswissenschaftliche Erkenntnisse aus dieser Studie, den beiden Machbarkeitsstudien und der systematischen Übersichtsarbeit zeigen, dass ein CBE Multikomponenten-Trainingsprogramm mit einer moderate Belastungsintensität, einem Belastungsumfang von 60 Minuten pro Trainingseinheit, einer Frequenz von zweimal pro Woche an zwei nicht aufeinanderfolgenden Tagen, für einen Zeitraum von insgesamt vier Monaten als praktikabel und wirksam empfohlen werden kann. Bei der Umsetzung ist eine biopsychosoziale Herangehensweise sinnvoll, die sich an dem Rahmenkonzept zur Multimorbidität orientiert. Für eine hohe Lebensqualität bis an das Lebensende ist dabei das Ziel individuelle motorische und kognitive Ressourcen zu fördern, um die Funktionsfähigkeiten im Alltag zu verbessern und die soziale Teilhabe zu stärken.

Schlussfolgerungen

Die aus dieser Dissertation gewonnenen Erkenntnisse tragen dazu bei, die Forschungslücke zu Trainingsinterventionen für nicht Gehfähige zu schließen, da hierfür gezielt die in der Forschung unterrepräsentierte Gruppe der nicht Gehfähigen adressiert wird. Dadurch entstehen neue Erkenntnisse für die Trainingswissenschaft durch Empfehlungen für eine gezielte und bedarfsgerechte Gestaltung und Steuerung eines wirksamen Trainings zur Förderung der gesundheitlichen Ressourcen. Zudem liefert die Dissertation einen besonderen Mehrwert durch Handlungsempfehlungen für Akteure in der Gesundheitsversorgung zur Umsetzbarkeit einer Trainingsintervention im Setting Altenpflege, die auch die in der Forschung unterrepräsentierten, mobilitätseingeschränkten BewohnerInnen adressiert.

Abstract

Background

Older adults, who live in nursing homes, are often characterized by multimorbidity, frailty and a high prevalence of dependency in activities of daily living (ADL). Without physical training, the residents are exposed to a constant decrease of motor resources such as hand grip strength, balance and mobility. The loss of these motor resources is also associated with reduced well-being and quality of life and a reduction in cognitive functions. Therefore, effective training measures to strengthen health resources and to prevent or delay disabilities in older institutionalized people have a high priority in health politics. Most interventional research studies in the nursing home setting are aimed at residents who are still able to walk. Since a large proportion of the residents in nursing homes often do not meet this motor inclusion criterion of the studies for participating in the training interventions, a conceptual gap arises in health care research. Hence, only little research that address the feasibility and effectiveness of a training program for nursing homes residents who are unable to walk has been conducted. Chair-based exercise (CBE) interventions represent an opportunity to make exercise possible for older people with restricted mobility and thus to promote functional motor and cognitive resources. However, the quality of studies on CBE interventions is often poor and there are no concrete instructions for practical implementation in the nursing home setting. In addition, there is no adequate examination of exercise principles and training parameters.

The aim of this research project was the development, evaluation and investigation of effectiveness of an exercise intervention to promote motor and cognitive functions and psychosocial well-being for nursing home residents who are unable to walk.

Methods

First, an exercise intervention was developed. For this purpose and to investigate the needs and resources of the residents, five qualitative interviews were conducted in a nursing home in Hamburg. Based on the recommendations of a task-force report for exercise with people in need of care, principles of exercise science and the results of the interviews, two multicomponent exercise programs were developed, one for the ambulatory and one multicomponent CBE program for the non-ambulatory nursing home residents (Publication 1). Simultaneously, the author carried out a systematic review on CBE interventions in nursing homes to ascertain the current state of research on interventions that specifically target residents who are unable to walk (Publication 2). Furthermore, a feasibility study was conducted to evaluate the exercise

program for *N=24* ambulatory residents and to investigate its feasibility, effectiveness and acceptance (Publication 3). On the basis of the results from the review and the feasibility study, the CBE program for those who are unable to walk was modified and further developed. The modified CBE program was carried out as part of a further feasibility study with a pre-post design to examine its effectiveness regarding *N=7* non-ambulatory residents' ability to perform activities of daily living (Publication 4). This was followed by a two-arm single-blinded randomized, controlled trial with *N*=52 non-ambulatory residents from four nursing homes in Bremen and Chemnitz (Publication 5). Motor function, cognition and psychosocial well-being were examined when entering the study (T1) and after 16 weeks of training (T2).

Results

The investigated multicomponent CBE program increased the residents' performance within all four tests of motor function (ADL, clinical manual dexterity, dynamic sitting balance, and hand grip strength), both cognitive tests (working memory and cognitive status) and remained stable within psychosocial outcomes (depression status and physical and mental well-being) while the control group showed continuous decrements over the course of 16 weeks. Moreover, the results of this study, both feasibility studies, and the systematic review indicate that a moderate intensity, 60 minutes per training session, two times per week, for a total of four months are feasible and effective training modalities for CBE in nursing home settings. As part of the implementation, a bio-psychosocial approach based on the framework concept for multimorbidity makes sense, with the aim of promoting individual motor and cognitive resources to improve functional performance in ADL and strengthen social participation for a high quality of life until the end of life.

Conclusion

The knowledge gained from this dissertation helps to close the research gap on exercise interventions for those who are unable to walk, a group which has so far hardly been considered in research and specifically addressed for this purpose. Hence, new knowledge for exercise science is gained by providing initial approaches and concrete recommendations for developing and conducting effective exercise interventions and evidence-based guidelines to promote health resources. In addition, this dissertation offers special added value for the practical implementation of health-promoting exercise programs in the nursing home setting, which also address residents who are unable to walk and are underrepresented in research.

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Abkürzungsverzeichnis

ACSM	American College of Sports Medicine
ADL	Activities of daily living
BDNF	Brain-derived neurotrophic factor
CBE	Chair-based exercise
IAGG-GARN	International Association of Gerontology and Geriatrics - Global Aging Research Network
PROCARE	Projekt - Prävention in stationären Pflegeeinrichtungen
SD	Standardabweichung (standard deviation)

1 Einleitung

Die Zahl der Menschen im Alter von über 80 Jahre steigt in Deutschland kontinuierlich an. In Folge dieses Anstiegs erhöht sich auch die Zahl der Pflegebedürftigen in vollstationärer Betreuung (Statistisches Bundesamt, 2021). Um diesen demografischen Veränderungen gerecht zu werden, besteht ein erhöhter Bedarf an präventiven Lösungen zur Förderung motorischer und kognitiver Funktionen sowie einer Reduktion der Pflegebedürftigkeit für mehr Lebensqualität im hohen Alter. Forschung und Entwicklung von gesundheitsfördernden Interventionen für diese hochaltrige Zielgruppe haben demnach eine hohe gesundheitspolitische Relevanz. Dafür ist eine genaue Betrachtung des Gesundheitszustandes von pflegebedürftigen BewohnerInnen der stationären Altenpflege sinnvoll. Dieser ist gekennzeichnet durch Multimorbidität, Gebrechlichkeit, Vulnerabilität, ein hohes Risiko für die Entstehung und das Fortschreiten von Behinderungen sowie den Verlust der Gehfähigkeit (Ferrucci et al., 2004; Kuhlmey, 2009; Scheidt-Nave et al., 2010; Valenzuela, 2012). Diese Faktoren führen zu starken Einbußen in der Selbstständigkeit bei Aktivitäten des täglichen Lebens (ADL), wie das An- und Auskleiden, Aufsetzen und Umsetzen sowie das selbstständige Bewältigen von Strecken im Wohnbereich (Covinsky et al., 2003), um z.B. am gesellschaftlichen Leben in der Einrichtung teilzunehmen. In Deutschland weisen 59% der BewohnerInnen in Altenpflegeeinrichtungen starke Limitierungen innerhalb der ADL durch motorische und kognitive Fähigkeitseinbußen auf (Statistisches Bundesamt, 2021). Zudem sind ohne regelmäßiges körperliches Training die motorischen Fähigkeiten für die Ausübung von ADL wie Handkraft, Gleichgewicht, Beinkraft und Mobilität einem stetigen Abbau ausgesetzt (Masciocchi et al., 2019; Seidler et al., 2010). Der Verlust dieser motorischen Ressourcen steht zudem in Zusammenhang mit einem reduzierten Wohlbefinden, einer reduzierten Lebensqualität (Kehyayan et al., 2016; Musich et al., 2018) und einem Abbau kognitiver Funktionen (Herold et al., 2019; Seidler et al., 2010).

Durch das im Jahr 2015 in Kraft getretene Präventionsgesetz (§ 5 Abs. 1 Satz 3 SGB XI) werden Trainingsmaßnahmen zur Stärkung der Gesundheitsressourcen und zur Vorbeugung oder Verzögerung von Behinderungen bei älteren pflegebedürftigen Menschen eine verstärkte gesundheitspolitische Priorität eingeräumt. Dadurch rückt die Förderung von vorbeugenden Leistungen zur Reduktion des Ressourcenabbaus in Pflegeheimen bei Pflegeversicherungen vermehrt in den Vordergrund. Es gilt dabei, dem Abbau motorischer und kognitiver Funktionen sowie psychosozialer Ressourcen gezielt entgegenzuwirken. Vor diesem Hintergrund entstand 2017 das Projekt PROCARE (Prävention in stationären Pflegeeinrichtungen), welches den Forschungsrahmen für die vorliegende Dissertation lieferte (Bischoff et al., 2018).

Um diese gebrechliche und vulnerable Zielgruppe zu adressieren, ist eine biopsychosoziale Herangehensweise sinnvoll, bei der die pflegebedürftigen Menschen im ganzheitlichen Kontext biologischer, psychologischer und sozialer Faktoren betrachtet werden (Wade & Halligan, 2017). Mit Rücksicht auf diese individuellen Kontextfaktoren sollen Trainingsprogramme auf die Bedürfnisse und Ressourcen abgestimmt werden. Einen vielversprechenden, ressourcenorientierten Ansatz zeigen Studien zu gruppenbasierten Multikomponenten-Trainingsprogrammen, die Ausdauer-, Kräftigungs-, Beweglichkeits- und Gleichgewichtsübungen kombinieren und positive Effekte auf die Selbstständigkeit zur Ausübung von ADL bei BewohnerInnen in Altenpflegeeinrichtungen fördern (Crocker et al., 2013). Des Weiteren konnte ein positiver Einfluss von Krafttraining auf kognitive Funktionen, wie z.B. exekutive Funktionen und das Arbeitsgedächtnis, in einer Übersichtsarbeit nachgewiesen werden (Herold et al., 2019). Zudem gibt es in einem Bericht der International Association of Gerontology and Geriatrics - Global Aging Research Network (IAGG-GARN) (de Souto Barreto et al., 2016) Empfehlungen für ein Multikomponenten-Training mit mobilen BewohnerInnen der stationären Altenpflege, es ist jedoch bisher nicht abschließend erforscht, wie sich Trainingsinterventionen inhaltlich bedarfsgerecht strukturieren lassen, um neben motorischen Verbesserungen die Kognition und das psychosoziale Wohlbefinden zu erhöhen oder zu erhalten.

Diese Empfehlungen beruhen ausschließlich auf Untersuchungen zu älteren Menschen, deren Gehfähigkeit noch erhalten ist. AltenpflegeheimbewohnerInnen, die in ihrer Mobilität bereits stark eingeschränkt und nicht mehr gehfähig sind, erfüllen oft nicht die Einschlusskriterien für die Teilnahme an Studien zu Trainingsinterventionen und es entsteht eine konzeptionelle Lücke in der Gesundheitsforschung (Schaeffer et al., 2016). Ein solcher Ausschluss von den Trainingsinterventionen schränkt die BewohnerInnen zudem in ihrer Teilhabe an sozialen Aktivitäten ein und kann dazu beitragen, dass diese sich zunehmend sozial isolieren (Ridda et al., 2010). Soziale Isolation und verminderte Teilhabe wirken sich wiederum negativ auf die Lebensqualität und das Wohlbefinden aus (Schaeffer et al., 2016) und tragen zu einem weiteren Abbau motorischer Ressourcen bei. Um diesen Konsequenzen des physischen und psychosozialen Ausschlusses nicht gehfähiger BewohnerInnen entgegenzuwirken und um die Forschungslücke zu schließen, bedarf es der Untersuchung von Trainingsinterventionen die gezielt die besondere Situation nicht Gehfähiger und deren Bedürfnisse und Ressourcen berücksichtigen. Studien die die Durchführbarkeit und die Effektivität solcher Trainingsprogramme für hochaltrige, nicht gehfähige BewohnerInnen in der stationären Altenpflege adressieren fehlen bislang. Daher müssen die bereits genannten Inhalte und Empfehlungen für ein Multikomponenten-

Training in eine adäquate Intervention für nicht gehfähige BewohnerInnen überführt und auf deren Bedürfnisse angepasst werden.

Sogenannte chair-based exercise (CBE) Interventionen stellen eine Möglichkeit dar, um ein Training auch für ältere Menschen mit Mobilitätseinschränkungen möglich zu machen und somit funktionelle motorische und kognitive Ressourcen bedarfsgerecht zu fördern (Anthony et al., 2013; Baum et al., 2003; Cebrià et al., 2014; Chen et al., 2015; Kuan et al., 2012; Nagai et al., 2011; Robinson et al., 2016; Thurm et al., 2011). Die Studienqualität von Untersuchungen zu CBE Interventionen ist jedoch oft gering und es gibt keine konkrete Anleitung für die praktische Umsetzung im Setting Altenpflege. Zudem fehlt eine adäquate Auseinandersetzung mit trainingswissenschaftlichen Prinzipien und Belastungsnormativen, wie genaue Informationen zur Trainingsform und Inhalt und der Belastungssteuerung von Intensität, Dauer, Umfang und Frequenz, um motorische und/oder kognitive Funktionen sowie Wohlbefinden zu fördern (Anthony et al., 2013; Mayer et al., 2011). Folglich bedarf es randomisiert kontrollierten Studien, um eine mit CBE modifizierte Multikomponenten-Trainingsintervention und deren Wirksamkeit für die multimorbide Zielgruppe der nicht Gehfähigen zu untersuchen.

Die vorliegende Dissertation liefert mit einer solchen Studie neue Erkenntnisse für ein gesundheitsförderliches CBE Training im Setting Altenpflege indem erstmalig trainingswissenschaftliche Belastungsnormative und Prinzipien gezielt und systematisch für die Zielgruppe der nicht gehfähigen BewohnerInnen eingesetzt wurden, sodass daraus konkrete Handlungsempfehlungen für die Praxis abgeleitet werden können. Zudem werden dadurch erstmalig Lösungsansätze zur Schließung einer Forschungslücke bei der bisher wenig untersuchten Kohorte der nicht gehfähigen BewohnerInnen in der Altenpflege präsentiert. Darüber hinaus bietet diese Forschungsarbeit einen besonderen Mehrwert durch Erkenntnisse für die praktische Umsetzung einer Trainingsintervention die nicht nur zu einer Schließung der Forschungslücke beitragen, sondern auch zur Schließung einer Versorgungslücke in der Altenpflege.

Für die Umsetzung dieser Dissertation wurde das folgende Vorgehen gewählt. Zu Beginn stand die Entwicklung und Bedarfsbestimmung (Publikation 1) eines Multikomponenten-Trainingsprogramms zur Förderung motorischer und kognitiver Ressourcen und des psychosozialen Wohlbefindens für nicht gehfähige BewohnerInnen in der stationären Altenpflege. Zeitlich parallel wurde eine systematische Übersichtsarbeit zur Evidenz von CBE zur Verbesserung motorischer und kognitiver Ressourcen sowie des psychosozialen Wohlbefindens durchgeführt (Publikation 2). Es folgte die Überprüfung der Machbarkeit der Multikomponenten-Trainingsintervention sowie die Untersuchung der Akzeptanz und Adhärenz der BewohnerInnen im Setting Altenpflege (Publikation 3 + 4). Abschließend widmete sich die Dissertation der Frage nach der Wirksamkeit einer Multikomponenten-Trainingsintervention, um motorische, kognitive und psychosoziale Ressourcen von nicht gehfähigen BewohnerInnen zu verbessern oder zu erhalten (Publikation 5).

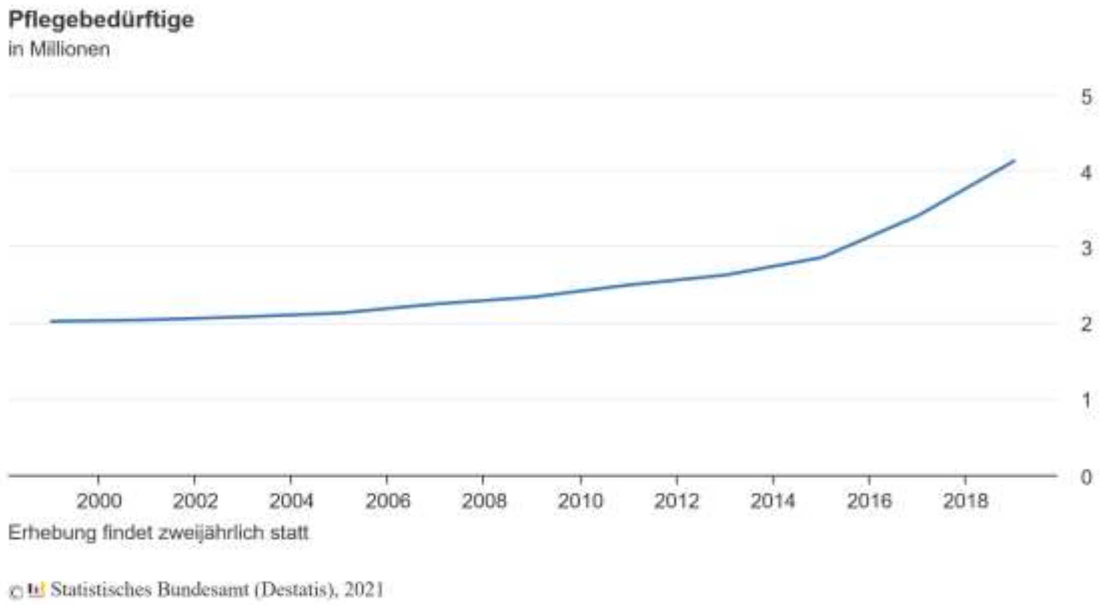
2 Theoretische Herleitung

2.1 Multimorbidität im Alter

Grundlegend für dieses Forschungsvorhaben ist die geriatrische Herausforderung einer progressiv steigenden Zahl von pflegebedürftigen Menschen (Statistisches Bundesamt, 2021). Bis zum Jahr 2019 gab es in Deutschland bereits 4,1 Millionen Pflegebedürftige (vgl. Abbildung 1) mit 820,000 Personen in vollstationärer Betreuung (Statistisches Bundesamt, 2021). In der stationären Altenpflege zeichnet sich dieser Trend durch eine steigende Zahl pflegebedürftiger Menschen ab, die im hohen Maß vulnerabel und gekennzeichnet durch Multimorbidität sind (Kojer, 2015; Scheidt-Nave et al., 2010).

Abbildung 1

Pflegebedürftige in Millionen (Statistisches Bundesamt, 2021)

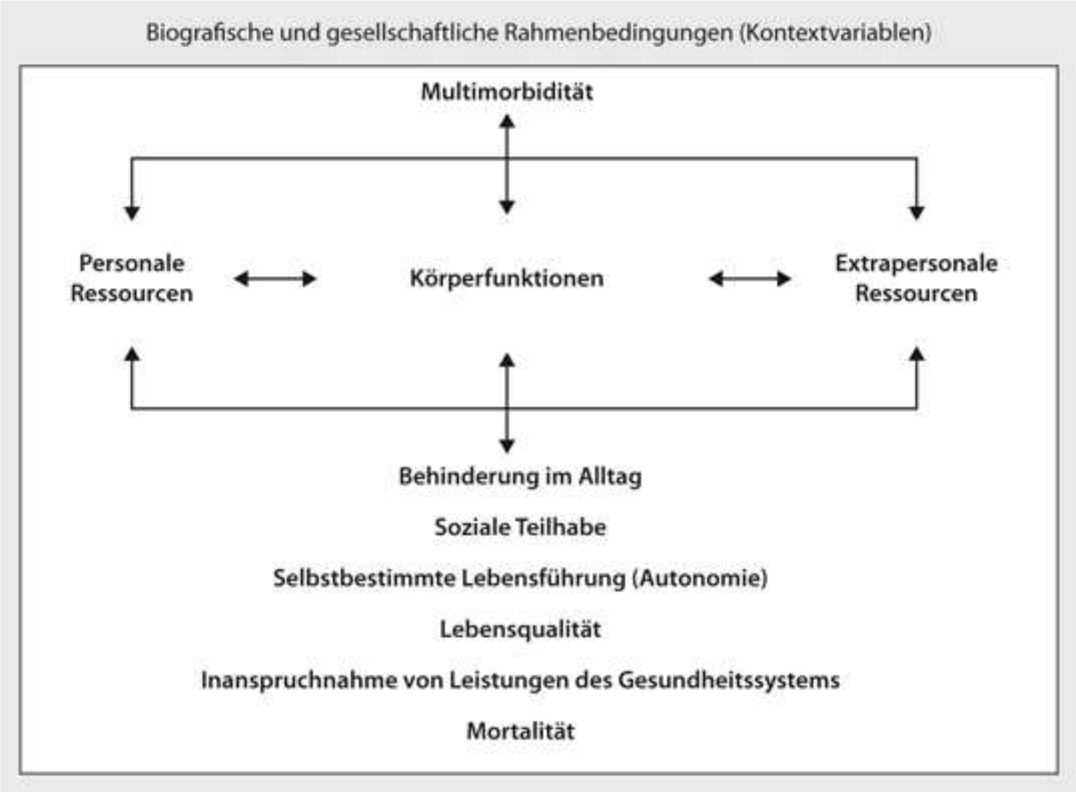


Multimorbidität wird definiert als mehrere gleichzeitig auftretende chronische oder akute Erkrankungen (Horn et al., 2012), durch die die alltagsrelevante Funktionsfähigkeit deutlich eingeschränkt und Betroffene zunehmend gebrechlicher werden (Peters et al., 2011) und einem erhöhten Sterberisiko unterliegen (Nunes et al., 2016). Dadurch ist die Multimorbidität ein erheblicher Belastungsfaktor für das Gesundheitssystem (Puth et al., 2017). Mit zunehmendem Alter steigt zusätzlich zur Pflegebedürftigkeit auch die Wahrscheinlichkeit für das Auftreten sowie die Komplexität von Multimorbidität (Clegg et al., 2013; Kuhlmey, 2009) und macht sie dadurch zu einer der wichtigsten Herausforderungen in der Gesundheitsforschung (Puth et al., 2017). Die u.a. von Fried und KollegInnen (2001) beschriebene Gebrechlichkeit bei älteren Menschen ist eine Konsequenz der Multimorbidität und gekennzeichnet durch ungewollten Gewichtsverlust, verminderte Handkraft, langsame Gehgeschwindigkeit oder den Verlust der Gehfähigkeit, Erschöpfung und niedrige körperliche Aktivität. Es besteht also eine Verbindung zwischen Multimorbidität und einer gesteigerten Gebrechlichkeit durch Einbußen in den Körperfunktionen (Slaets, 2006; Walston et al., 2006). Zudem konnte ein Zusammenhang zwischen einer erhöhten Gebrechlichkeit und einer Reduktion des psychosozialen Wohlbefindens (Crocker et al., 2019) und kognitiver Funktionen gezeigt werden (Furtado et al., 2020). Physische und kognitive Gebrechlichkeit können sich dabei gegenseitig verstärken (Canevelli et al., 2015). Folglich nimmt die Pflegebedürftigkeit zu, wenn ein multimorbider Mensch den Alltag aufgrund physischer, kognitiver und psychosozialer Einschränkungen nicht mehr allein bewältigen kann (Scheidt-Nave et al., 2010).

Vor diesem Hintergrund und der steigenden Zahl Pflegebedürftiger, wird die Notwendigkeit von Forschung und präventiven Maßnahmen zur Gesundheitserhaltung und Gesundheitsförderung dieser hochaltrigen Zielgruppe deutlich. Scheidt-Nave und KollegInnen (2010), liefern dazu ein Rahmenkonzept zur Multimorbidität, welches den pflegebedürftigen Menschen im biografischen und gesellschaftlichen Kontext betrachtet. Dieses Modell beschreibt eine Vielzahl von Wechselwirkungen zwischen der Multimorbidität, den Körperfunktionen, personalen und extrapersonalen Ressourcen sowie daraus resultierende Konsequenzen wie die Alltagsbewältigung, soziale Teilhabe, selbstbestimmte Lebensführung und Lebensqualität (vgl. Abbildung 2).

Abbildung 2

Rahmenkonzept zur Multimorbidität (Scheidt-Nave et al., 2010)



Die personalen und extrapersonalen Ressourcen unterstützen die älteren Menschen dabei, mit den Herausforderungen von Multimorbidität und Funktionseinbußen umzugehen oder diese zu bewältigen. Dabei wird deutlich, dass Einschränkungen der Körperfunktionen durch Multimorbidität immer auch in Interaktion mit der Umwelt stehen und erst zu einer Behinderung werden, wenn dadurch die Teilhabe eingeschränkt ist (Peters et al., 2011). Bei dieser Interaktion spielt es zudem eine entscheidende Rolle welche personalen und extrapersonalen Ressourcen einem Menschen als Potential zur Verfügung stehen. Personale Ressourcen wie die Motivation zu gesundheitsbewusstem Verhalten oder körperliche Fitness und extrapersonale Ressourcen wie die Lebensbedingungen und Möglichkeiten zur aktiven Lebensgestaltung im sozialen Umfeld, beeinflussen im Wesentlichen den Umgang mit funktionellen Einschränkungen und Erkrankungen. Dabei hat bei multimorbiden Menschen die Selbstständigkeit im Alltag und die soziale Teilhabe einen wesentlichen Einfluss auf eine höhere Lebenszufriedenheit (Kehyayan et al., 2016). Weiter zeigt sich, dass gebrechliche, ältere Menschen ein höheres allgemeines Wohlbefinden aufweisen, wenn sie sozial gut eingebunden sind und an Aktivitäten teilnehmen können (van der Vorst et al., 2017). Dies deckt sich mit BewohnerInnenbefragungen, die gezeigt haben, dass die Möglichkeit zur Teilhabe an Aktivitäten für die BewohnerInnen in der Altenpflege einen großen Stellenwert hat (Nygaard et al., 2020). Multimorbidität kann allerdings auch durch Funktionseinschränkungen die Teilhabemöglichkeiten an der Umwelt verändern und dadurch die Selbstständigkeit reduzieren (Peters et al., 2011). Die aktive Auseinandersetzung mit der Umwelt hat jedoch auch einen unbestreitbar positiven Einfluss auf die physische und psychosoziale Gesundheit (Peters et al., 2011) während eine motorische und soziale Inaktivität und Isolation von der Umwelt einen negativen Einfluss auf die gesundheitsbezogene Lebensqualität aufweist (Kagwa et al., 2018).

Trotz Multimorbidität gelingt es einem Teil der älteren Menschen personale und extrapersonale Ressourcen für sich zu nutzen und sich dadurch einen ausreichenden Grad an Wohlbefinden zu erhalten (Lacruz et al., 2010). Für Akteure in der Gesundheitsförderung und Prävention gilt es daher das Potential für solche Ressourcen zu identifizieren und zu stärken. Der Gesetzgeber hat zu diesem Zweck 2015 das Präventionsgesetz zur Stärkung der Gesundheitsförderung und der Prävention in der stationären Altenpflege (§ 5 Abs. 1 Satz 3 SGB XI) verabschiedet, durch das u.a. die Motorik, Kognition und psychosoziales Wohlbefinden von Pflegebedürftigen durch bedarfsgerechte Interventionen gestärkt werden sollen. Interventionen sollten demnach gezielt die individuellen Ressourcen und Kontextfaktoren der Pflegebedürftigen berücksichtigen, um trotz gegebener gesundheitlicher und funktioneller Einschränkungen, eine höchstmögliche Selbstständigkeit bei bestmöglicher Lebenszufriedenheit zu erhalten (Riedl et al., 2013; Wöhl et al., 2017). Dabei gilt es, die Ressourcen der multimorbiden Menschen gezielt und teilhabeorientiert zu fördern und vor dem Hintergrund der biografischen und gesellschaftlichen Rahmenbedingungen und Kontextfaktoren bedarfsgerechte Interventionen zu entwickeln. Bei der Entwicklung geeigneter Trainingsinterventionen für BewohnerInnen in der Altenpflege ist daher eine an dem Rahmenkonzept zur Multimorbidität (Scheidt-Nave et al., 2010) orientierte biopsychosoziale Herangehensweise (Wade & Halligan, 2017) sinnvoll, die den pflegebedürftigen Menschen ganzheitlich im Setting der Altenpflegeeinrichtung und dem Einfluss personaler und extrapersonaler Kontextfaktoren und Ressourcen betrachtet. Im Vordergrund einer bedarfsgerechten Prävention steht demnach nicht das Beseitigen von vorhandenen Erkrankungen und Einschränkungen, sondern vielmehr eine Förderung der individuellen motorischen und kognitiven Ressourcen, um die Funktionsfähigkeiten im Alltag und die soziale Teilhabe der BewohnerInnen zu verbessern oder zu erhalten.

Dieses Ziel wird im Rahmen dieser Dissertation verfolgt, um aus den Ergebnissen Handlungsempfehlungen für evidenzbasierte Trainingsinterventionen in der Altenpflege ableiten zu können. Damit leistet die Dissertation einen Forschungsbeitrag mit dem Fokus auf eine in der Forschung schwer erreichbare Zielgruppe mit besonderem Versorgungsbedarf. Die bisher wenig untersuchten BewohnerInnen die in ihrer Mobilität stark eingeschränkt und auf einen Rollstuhl angewiesen sind, werden in dieser Dissertation gezielt adressiert. Zudem liefert die Dissertation im folgenden Kapitel eine evidenzbasierte Auseinandersetzung mit den motorischen und kognitiven Ressourcen von BewohnerInnen in der Altenpflege unter Berücksichtigung trainingswissenschaftlicher Prinzipien und Belastungsnormative.

2.2 Training gesundheitlicher Ressourcen von AltenpflegeheimbewohnerInnen

2.2.1 Trainierbarkeit motorischer Ressourcen

Trotz Veränderungen in der Anpassungsfähigkeit der Muskulatur und des Herz-Kreislaufsystems im Alter (Blasco-Lafarga et al., 2020), ist es mittlerweile unumstritten, dass die motorischen Ressourcen Ausdauer, Kraft und Koordination auch im hohen Alter noch trainierbar sind (Hottenrott, 2017; Chodzko-Zajko et al., 2009; Mayer et al., 2011; Zaleski et al., 2016). Dies zeigt sich bei Untersuchungen mit Menschen im hohen Alter durch eine lohnende Trainierbarkeit der Kraft und der Ausdauer (Cadore et al., 2014). Ein Training der Ausdauer führt demnach zu kardiovaskulären und kardiorespiratorischen Anpassungen im Sinne einer Ökonomisierung des Energiestoffwechsels mit verbesserter aerober Kapazität (Cadore et al., 2014). Zudem zeigt sich, dass durch Krafttraining auch im hohen Alter neuromuskuläre Anpassungen im Sinne einer Zunahme der Maximalkraft und Kraftausdauer erzielt werden können (Cadore et al., 2014; Grgic et al., 2020). In weiteren Untersuchungen mit älteren Menschen konnte eine gute motorische Lernfähigkeit (Mooney et al., 2019) sowie neurophysiologische Anpassungen durch ein Training für das Gleichgewicht und die Koordination festgestellt werden (Dunsky, 2019). Diese motorischen Ressourcen werden bei der Ausübung von ADL benötigt und können somit bei BewohnerInnen in der Altenpflege durch ein an den Fähigkeiten und Bedürfnissen orientiertes Training gefördert werden (Schaeffer & Büscher, 2009; Weening-Dijksterhuis et al., 2011). Bleibt eine Förderung durch ein regelmäßiges Training aus, sind inaktive BewohnerInnen jedoch einem stetigen Abbau motorischer Ressourcen wie Handkraft (-2,2% monatlich), Beinkraft (-3,5% monatlich), Gleichgewicht (-2% monatlich) und Mobilität (-2,1% monatlich) ausgesetzt (Masciocchi et al., 2019). Durch die Inaktivität kommt es zudem zu einem Abbau der aeroben Ausdauer (Toraman, 2005) und einer Verstärkung funktioneller motorischer Einschränkungen bei der selbstständigen Ausübung von ADL (Douma et al., 2017; Jansen et al., 2017; Valenzuela et al., 2018). Gezielte Trainingsinterventionen können den Prozess des fortschreitenden Verlustes der motorischen Funktionen verlangsamen (Crocker et al., 2013). Neuere Studien zeigen, dass die Fähigkeiten zur Ausübung von ADL bei PflegeheimbewohnerInnen durch Multikomponenten-Training verbessert werden kann und sich dies positiv auf das Wohlbefinden und die Lebensqualität auswirkt (Campbell et al., 2021; Senik et al., 2021). Auch tragen Interventionen mit Ausdauer-, Kraft- und/oder Koordinationstraining zu einer Verzögerung des kognitiven Abbaus im Alter bei und können altersbedingte Erkrankungen verhindern (Falck et al., 2019; Northey et al., 2018; Voelcker-Rehage et al., 2011). Es gibt solide Evidenz, dass die neurobiologischen Anpassungen eines Krafttrainings, mit Übungen zur Steigerung der Muskelkraft oder für die Muskelhypertrophie, auch einen wesentlichen Einfluss auf verschiedene kognitive Domänen wie das Arbeitsgedächtnis und die exekutiven Funktionen haben (Herold et al., 2019). Untersuchungen zeigten, dass durch Training das Wachstum von Nervenzellen im Hippocampus und neurochemische Konzentrationsveränderungen durch eine Ausschüttung verschiedener Myokine wie den Wachstumsfaktor BDNF (Brain-derived neurotrophic factor) ausgelöst werden (Erickson et al., 2011). Dieser Effekt sorgt dafür, dass durch ein Ausdauer- oder Krafttraining neue Verknüpfungen im Gehirn gebildet und somit die Gedächtnis- und Lernfähigkeit stabilisiert oder verbessert werden kann (Basso & Suzuki, 2017; Marston et al., 2019).

2.2.2 Trainingsform und Inhalt von Interventionen

Um eine geeignete Trainingsintervention zur Förderung motorischer, kognitiver und psychosozialer Ressourcen für die Zielgruppe der multimorbiden AltenpflegeheimbewohnerInnen zu entwickeln, stellt sich zunächst die Frage nach der passenden Trainingsform bezogen auf Trainingsinhalt,-methode und -mittel. Studien zu Trainingsinterventionen für BewohnerInnen in der Altenpflege unterscheiden sich stark in Bezug auf die Trainingsform und seine Inhalte (Campbell et al., 2021). Eine Übersicht von Schaeffer und KollegInnen (2016) zeigte den Einsatz von Trainingsprogrammen zur Verbesserung der Beweglichkeit (Netz et al., 2007) oder des Gleichgewichts (Toulotte et al., 2003) sowie Multikomponenten-Trainingsprogramme mit einer Kombination aus mehreren motorischen Fähigkeitskomponenten wie Kraft, Ausdauer, Gleichgewicht, Koordination und aufgabenspezifischem ADL-Training (Jansen et al., 2014; Littbrand et al., 2009). Außerdem zeigten Interventionen, die ein Multikomponenten-Training mit zusätzlichen kognitiven Übungen kombinieren, vielversprechende Ergebnisse hinsichtlich einer Verbesserung motorischer (Jansen et al., 2015; Wollesen et al., 2017; Wollesen & Voelcker-Rehage, 2014) und kognitiver (Schoene et al., 2015) Funktionen wie Aufmerksamkeit und exekutive Funktionen bei älteren Erwachsenen sowie bei Menschen mit Demenz hinsichtlich einer Verbesserung der Funktionen für ADL (Kruse et al., 2021; Machado et al., 2020). Darüber hinaus wird ein Multikomponenten-Training kombiniert mit kognitiv-motorischen Übungen als vielversprechende Möglichkeit zur Förderung motorischer und kognitiver Ressourcen für ein Training mit älteren Menschen empfohlen (de Souto Barreto et al., 2016) und scheint einem Training mit nur einer motorischen Komponente überlegen zu sein (Cadore et al., 2013). Eine Übersichtsarbeit, die verschiedene Trainingsarten für ältere Erwachsene vergleicht, bestätigt die Empfehlung, dass mehrere Trainingskomponenten wirksam sind, um die motorische und kognitive Gesundheit zu verbessern (Netz, 2019). Die AutorInnen schlussfolgerten, dass ein motorisches Training kombiniert mit kognitiven Anforderungen im Sinne eines Dual-Task Trainings eine effektive Möglichkeit darstellt, um kognitive Ressourcen zu verbessern (Netz, 2019). Die meisten Studien zu Multikomponenten-Trainingsprogrammen untersuchten jedoch gesunde ältere Erwachsene. Über die Wirksamkeit von Multikomponenten-Trainingsprogrammen, die Ausdauer, Kraft, aufgabenspezifisches Koordinationstraining für ADL und motorisch-kognitive Übungen zur Gesundheitsförderung bei PflegeheimbewohnerInnen integrieren, ist weniger bekannt. Erste Studien, die ein Multikomponenten-Programm einschließlich Schritt- und Gehübungen untersuchten, zeigten jedoch auch Vorteile hinsichtlich motorischer Funktionen bei AltenpflegeheimbewohnerInnen (Arrieta et al., 2019; Arrieta et al., 2018) sowie der Lebensqualität und ADL bei gebrechlichen älteren Menschen (Campbell et al., 2021).

2.2.3 Steuerung der Belastungsnormative

Zusätzlich zur sinnvollen Auswahl der Trainingsform gilt es die Belastungsnormative bedarfsgerecht und individualisiert auf die Zielgruppe abzustimmen, um somit die Trainingsbelastung im Sinne eines optimalen Anpassungsprozesses zielführend steuern zu können (Herold et al., 2019). Zu berücksichtigen sind dabei die Belastungsnormative Umfang, Intensität, Dauer, Häufigkeit, Dichte und Ausführung (Hottenrott, 2017). In der angloamerikanischen Literatur werden die Belastungsnormative zur Trainingsgestaltung oft mithilfe der F.I.T.T. principles beschrieben (Garber et al., 2011). Diese zentrieren die Faktoren frequency (Trainingshäufigkeit), intensity (Trainingsintensität), time (Trainingsdauer/Trainingsumfang) und type (Form des Trainings). Eine Übersicht über die für die Trainingsgestaltung relevanten Belastungsnormative wird in Tabelle 1 dargestellt. Die kontinuierliche Anpassung des Trainingsvolumens an die individuelle Leistungsfähigkeit der BewohnerInnen und diese als progressive Herausforderung (overload) zu organisieren, gilt als wichtige Voraussetzung für eine muskuläre oder kardiovaskuläre Adaptation (Chodzko-Zajko et al., 2009; Donath & Faude, 2020; Herold et al., 2019;

Jahanpeyma et al., 2021; Schoenfeld et al., 2021). Eine solche – an trainingswissenschaftlichen Prinzipien orientierte – Trainingssteuerung ist möglich durch eine Steigerung des Trainingsvolumens im Sinne der Trainingsdauer (mehr Wiederholungen, mehr Trainingssätze, längere Gehstrecke, längere Trainingszeit), Trainingshäufigkeit (mehr Trainingseinheiten pro Woche) oder der Trainingsintensität (Zusatzgewicht, erhöhter Widerstand, schwerere Übungsvariante).

Tabelle 1

Belastungsnormative für die Trainingsgestaltung (in Anlehnung an Donath & Faude, 2020)

	Beschreibung
Trainingsintensität	Die Trainingsintensität beschreibt den Grad der Anstrengung (niedrig, moderat, hoch)
Trainingshäufigkeit/ Trainingsfrequenz	Die Trainingshäufigkeit wird definiert über die Anzahl an Trainingseinheiten im Rahmen eines bestimmten Zeitintervall (3x Täglich, 2x pro Woche)
Trainingsdauer/ Trainingsumfang	Die Trainingsdauer gibt an wie lange oder wie oft eine bestimmte Übung ausgeführt werden soll (30 Wiederholungen) oder eine komplette Trainingseinheit dauert (20 Minuten)
Trainingsform	Die Form des Trainings wird definiert durch den Charakter oder den Schwerpunk mit dem eine Trainingseinheit oder eine Intervention gestaltet wird (Ausdauer, Kraft, Koordination, Kognitiv-motorisches Training)

Da Pflegebedürftige hinsichtlich ihrer Ressourcen und motorischen sowie kognitiven Leistungsfähigkeit sehr heterogen sind (Grönstedt et al., 2011), stellt die Belastungssteuerung eine besondere Herausforderung dar. Ein Bericht der IAGG-GARN enthält grobe Empfehlungen zur Steuerung der Belastung von Multikomponenten-Trainingsprogrammen für pflegebedürftige Menschen (de Souto Barreto et al., 2016). In diesem Bericht wird betont, dass eine moderate Trainingsintensität, die kontinuierlich an die Fähigkeiten der BewohnerInnen angepasst wird, am vorteilhaftesten ist. Herz- und Atemfrequenz sollten dabei spürbar erhöht werden, ohne Atemnot oder übermäßige Erschöpfung zu verursachen (de Souto Barreto et al., 2016). Darüber hinaus sollte ein Training nach Darstellung der AutorInnen einen Trainingsumfang von 13–15 Wiederholungen in einem oder zwei Trainingssätzen umfassen sowie eine Trainingsfrequenz und -dauer von zweimal pro Woche für 45 Minuten anstreben (de Souto Barreto et al., 2016). In vielen Interventionen für PflegeheimbewohnerInnen fehlen jedoch genaue Informationen über die Gestaltung und Überwachung der Belastungsnormative. Es finden sich zwar Angaben zu Trainingsumfang und -frequenz; die Trainingsintensität wird jedoch häufig nur in niedrig, moderat oder hoch eingestuft, ohne die gezielte Steuerung und Anpassung dieses Belastungsfaktors zu beschreiben. Die Belastungssteuerung ist bei der Zielgruppe zwar eine besondere Herausforderung, zugleich jedoch ein entscheidender Faktor, um Aussagen zu Dosis-Wirkungsbeziehungen treffen zu können (Herold et al., 2019). Es gilt die Gefahr einer Überlastung gering zu halten und gleichzeitig möglichst alle TeilnehmerInnen einem für eine Adaptation ausreichend überschwelligen Trainingsreiz auszusetzen. Eine Belastungssteuerung, die sich an standardisierten Wiederholungszahlen und Übungen orientiert, führt zu stark unterschiedlichen Anpassungen bei Untrainierten (Bouchard & Rankinen, 2001) und kann daher nur einen Teil der BewohnerInnen an ihrer individuellen Schwelle der Leistungsfähigkeit abholen. Für die Mehrheit ist es deshalb wahrscheinlich, dass ein trainingswirksamer Reiz durch Unterforderung ausbleibt. Deshalb lassen sich aus vielen Interventionsstudien oft nur ungenaue Empfehlungen zu einer geeigneten Belastungssteuerung ableiten, die für eine Umsetzung in der Praxis aber unbedingt nötig wären. Ein Trainingsprogramm sollte daher mit Rücksicht auf eine systematische und individuelle Belastungssteuerung konzipiert sein (Zaleski et al., 2016). Dafür ist eine stetige Überwachung und leistungsgerechte Anpassung des Trainings nötig, um die individuellen Fähigkeiten der TeilnehmerInnen zu berücksichtigen (Grönstedt et al., 2013; Pol et al., 2020) und die motorischen Ressourcen im Sinne einer adäquaten Reizsetzung optimal zu fördern (Hottenrott, 2017). Eine progressive Steigerung bedarf jedoch einer regelmäßigen Überprüfung der passenden Trainingsintensität. Hierfür gibt es verschiedene Methoden, wie das Messen der relativen Herzfrequenz in Bezug auf die alters-vorhergesagte maximale Herzfrequenz (Garber et al., 2011). Eine praktikable Lösung, die sich ohne technischen Aufwand umsetzen lässt und bereits im Setting Rehabilitation eingesetzt wurde (Levinger et al., 2004; Mitchell et al., 2019), ist die Abfrage des subjektiven Anstrengungsempfindens mithilfe der Borg Skala (Borg, 1998). Ein Punktwert von 13-14 auf der Skala entspricht einer moderaten Intensität, die in dem Expertenbericht für Sport mit BewohnerInnen in der Altenpflege (de Souto Barreto et al., 2016) empfohlen wird.

Grundsätzlich werden Trainingsform und Belastungssteuerung immer durch die Zielgruppe mit Rücksicht auf die Zielstellung und das Ausgangsniveau bestimmt (Donath & Faude, 2020). Vor diesem Hintergrund wurden bedarfsorientierte Trainingsprogramme mit Rücksicht auf eine gezielte Belastungssteuerung im Setting Altenpflege im Hinblick auf die Aspekte Machbarkeit und Wirksamkeit bisher noch nicht ausreichend untersucht (Horn et al., 2013; Richards et al., 2018). Um diese Forschungslücke zu schließen, ist die Überprüfung der Machbarkeit (Publikation 3 + 4) und Wirksamkeit (Publikation 5) zentraler Bestandteil der vorliegenden Dissertation.

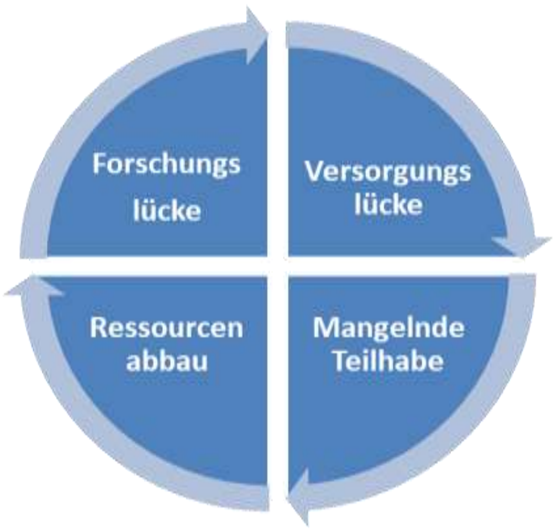
2.3 Training für nicht gehfähige BewohnerInnen in der Altenpflege

Aufgrund von Muskelschwäche und Gleichgewichtsdefiziten benötigen in deutschen Altenpflegeeinrichtungen etwa 40% einen Rollstuhl, um sich selbstständig fortbewegen zu können (Horn et al., 2012). Bei diesen nicht gehfähigen BewohnerInnen in der stationären Altenpflege handelt es sich daher um Personen, die im hohen Maße vulnerable sind und Alltagsaktivitäten mit erheblichen motorischen Einschränkungen bewältigen müssen (Karmarkar et al., 2011). Verschiedene motorische und kognitive Ressourcen, um den Alltag weitestgehend autonom bewältigen zu können sind zwingend erforderlich. Dies lässt sich exemplarisch anhand eines üblichen morgendlichen Tagesablaufs vom Bett bis zum Frühstückstisch verdeutlichen. Das Aufstehen beginnt mit einem Transfer vom Bett in den Rollstuhl und erfordert ein ausreichend funktionelles Gleichgewicht (Tsang et al., 2015) sowie Kraft in den oberen Extremitäten (Tsai et al., 2014). Beim An- und Auskleiden sowie der eigenständigen Körperpflege werden sowohl kognitive (exekutive Funktion, Handlungsplanung) als auch motorische Fähigkeiten (Gleichgewicht, Kraft im Oberkörper, Feinmotorik) benötigt (Mlinac & Feng, 2016). Damit wird deutlich, dass die Leistungsfähigkeit im Oberkörper einschließlich Kraft und Feinmotorik eine wichtige Rolle bei ADL spielen (Woloszyn et al., 2021). Eine ausreichende Mobilität um schließlich den Weg vom eigenen Zimmer zum Frühstückssaal mit dem Rollstuhl selbstständig zu bewältigen, erfordert räumliche Orientierungsfähigkeit (Ring et al., 2018; Wollesen et al., 2020), Hand- und Armkraft, Ausdauer und Beweglichkeit der oberen Extremitäten (Requejo et al., 2015). Als Konsequenz einer schwachen Muskulatur in den oberen Extremitäten empfinden es viele BewohnerInnen als zu schwer, sich mit ihrem Rollstuhl fortzubewegen (Wołoszyn et al., 2021). Sich selbstständig in der gewohnten Umgebung fortbewegen zu können hat dabei aber einen wesentlichen Einfluss auf die Lebensqualität, das Wohlbefinden und die soziale Teilhabe (Karakaya et al., 2009; Mortenson et al., 2012). Der aktive Gebrauch und das Training dieser motorischen Ressourcen minimiert das Risiko für die Entstehung von funktionellen Einschränkungen und Limitationen bei ADL (Cunningham et al., 2020).

In der Forschung findet die Zielgruppe der nicht gehfähigen BewohnerInnen bisher kaum Berücksichtigung. Gut untersuchte Trainingsinterventionen zur Verbesserung der Motorik umfassen typischerweise Übungen, die die Fähigkeit zum Stehen oder Gehen erfordern (Gillespie et al., 2009; Jahanpeyma et al., 2021). Bestehende Trainingsempfehlungen für BewohnerInnen in der Altenpflege schließen die BewohnerInnen mit starken Mobilitätseinschränkungen nicht mit ein (de Souto Barreto et al., 2016). Studien die Interventionen für Gehfähige untersucht haben, zeigten bereits Verbesserungen bezüglich Gangsicherheit und Sturzrisiko (Bjerk et al., 2019; Hewitt et al., 2018; Schoene et al., 2015; Thomas et al., 2010; Toots et al., 2018; Wollesen et al., 2017) sowie Gebrechlichkeit (Arrieta et al., 2019), ADL (Littbrand et al., 2009) und Leistungsfähigkeit der oberen und unteren Extremitäten (Arrieta et al., 2018). Allerdings können sehr gebrechliche BewohnerInnen mit schwacher Balance und Mobilität, die auf einen Rollstuhl angewiesen sind, nicht an Programmen mit Geh- oder Stehübungen teilnehmen und erfüllen somit nicht die Einschlusskriterien dieser Studien. Folglich existiert eine Lücke in der Gesundheitsforschung zu Trainingsinterventionen mit Hochaltrigen, die geschlossen werden muss (Anthony et al., 2013). Denn durch diese Lücke werden die Ressourcen von nicht gehfähigen BewohnerInnen in der Forschung nicht angemessen berücksichtigt. In der Praxis fehlt es daher unweigerlich an gut untersuchten Empfehlungen für die Umsetzung angemessener Trainingsinterventionen für BewohnerInnen die nicht gehen können. Aufgrund mangelnder Empfehlungen herrscht somit auch eine Versorgungslücke. Die BewohnerInnen werden nicht ausreichend mit Trainingsangeboten versorgt, die die individuellen Ressourcen nicht Gehfähiger berücksichtigen. Daraus resultiert wie in einem Teufelskreis eine erhöhte Inaktivität und verminderte soziale Teilhabe, was wiederum den weiteren Abbau kognitiver und motorischer Ressourcen begünstigt (vgl. Abbildung 3).

Abbildung 3

Teufelskreis aus mangelnder Teilhabe, Ressourcenabbau und einer Forschungs- und Versorgungslücke in der Altenpflege (eigene Darstellung)



Um den Teufelskreis zu unterbrechen, sind bedarfsgerechte Interventionen nötig, die auch nicht gehfähige BewohnerInnen einschließen. Hierfür bieten CBE Interventionen eine gute Möglichkeit, um ein Training in ausschließlich sitzender Position auch für ältere Menschen mit Mobilitätseinschränkungen möglich zu machen und somit motorische und kognitive Ressourcen zu fördern (Anthony et al., 2013; Robinson et al., 2016; Robinson et al., 2018). Eine Studie, die drei verschiedene CBE Trainingsprogramme mit je nur einer Trainingskomponente untersucht hat, konnte zum Teil positive Effekte zur Aufrechterhaltung der Unabhängigkeit und Mobilität in Pflegeheimen zeigen, kommt aber zu dem Schluss, dass ein CBE Trainingsprogramm mit mehreren Komponenten bessere Ergebnisse liefern könnte und deshalb zukünftig untersucht werden sollte (Cancela Carral et al., 2017). Das im Rahmen dieser Forschungsarbeit entwickelte Multikomponenten-Trainingsprogramm für nicht gehfähige BewohnerInnen orientiert sich an den motorischen Einschränkungen und besonderen Bedürfnissen und Ressourcen der Zielgruppe und wurde deshalb als CBE Trainingsprogramm konzipiert. Dieses adressiert im Schwerpunkt Übungen zur Förderung von den verschiedenen Komponenten Kraft, Ausdauer und Koordination im Rumpf und Oberkörper sowie eine gezielte Förderung der Fähigkeiten zur Durchführung von ADL. Die Trainingsform hat demnach den Charakter eines Multikomponenten-Trainings, da es verschiedene Komponenten der motorischen Leistung fördert. Allerdings ist es für die Umsetzung als CBE Training modifiziert. Damit wird der Ansatz verfolgt, ein auf die spezielle Zielgruppe zugeschnittenes Training anzubieten und kein „one size fits all" Programm für alle BewohnerInnen zu entwickeln.

Ausgewählt wurden Übungen für die Kraft in den Händen, da eine Schwäche der Handkraft ein wesentliches Merkmal von AltenpflegeheimbewohnerInnen darstellt (Granic et al., 2016) und für eine fortgeschrittene Gebrechlichkeit steht (Syddall et al., 2003). Neben der Kraft wird zudem ein gutes funktionelles Gleichgewicht im Sitzen bei zahlreichen ADL, wie Schuhe anziehen, Körperpflege oder der Transfer vom Rollstuhl ins Bett, benötigt (Katz-Leurer et al., 2009). Daher zielen verschiedene Übungen darauf ab, das funktionelle Gleichgewicht in sitzender Position zu fördern, indem sich der Oberkörper bei der Durchführung in verschiedene Richtungslagen begeben und dabei aktiv stabilisieren muss. Der Einsatz verschiedener Trainingsmaterialien, wie Bälle, Gymnastikstäbe, Tücher und Alltagsgegenstände, soll dabei helfen alltagsnahe Situationen nachzustellen und die für die Umsetzung nötigen motorischen und auch kognitiven Funktionen aufgabenspezifisch zu trainieren. BewohnerInnen sollen in den Übungen einen Zweck erkennen, der für die Bewältigung des Alltags bedeutsam und nachvollziehbar ist. So soll das Trainingsprogramm eine möglichst hohe Adhärenz schaffen. Dafür wurden kognitiv-motorische Übungen, die sich bei Interventionen mit gehfähigen, älteren Erwachsenen als vielversprechend erwiesen haben (Wollesen & Voelcker-Rehage, 2014), für die Durchführung in sitzender Position modifiziert. Dies ist sinnvoll, da auch nicht gehfähige BewohnerInnen bei vielen Alltagsaktivitäten die Fähigkeit benötigen, neben der motorischen Umsetzung zeitgleich kognitive Informationen zu verarbeiten (Voelcker-Rehage & Alberts, 2007). Hierzu zählen das

Kochen einer Tasse Tee oder das An- und Auskleiden. Das Training mit alltagsnahen Gegenständen schult zudem die Feinmotorik der Hände. Dies ist ebenfalls für viele ADL, wie das Schreiben mit einem Stift, das Öffnen einer Tür oder das Bezahlen mit Kleingeld, von Bedeutung. Ein Abbau dieser Fähigkeiten ist im Alter üblich und führt zu vermehrten Einschränkungen im Alltag (Hoogendam et al., 2014).

Unter Berücksichtigung trainingswissenschaftlicher Belastungsnormative wurde das Training im Verlauf regelmäßig mithilfe der Borg Skala (Borg, 1998) auf den Grad der Belastung überprüft und wenn möglich progressiv gesteigert. Dies geschah bei Ausdauer- und Kraftübungen über eine Anpassung von Belastungsumfang (mehr Wiederholungen von 5 – 10 -15- 20, mehr Trainingssätze 1 – 2 – 3) oder Belastungsintensität (Zusatzgewicht 1 oder 2 kg, erhöhter Wiederstand, schwerere Übungsvariante). Bei koordinativen oder kognitiv-motorischen Übungen wurden der Schwierigkeitsgrad mit der Zeit gesteigert (z.B. zwei Bälle statt einem, zusätzlich Rückwärtszählen während einer Übung). Die konkrete Übungsauswahl basiert auf der Grundlage von Empfehlungen der IAGG-GARN für BewohnerInnen von Pflegeheimen (de Souto Barreto et al., 2016). Weiter wurden Übungen berücksichtigt, die sich in zuvor veröffentlichten Interventionsstudien als vorteilhaft für ein Training mit älteren Menschen (Baker et al., 2007; Wollesen & Voelcker-Rehage, 2014) und Pflegebedürftigen (Arrieta et al., 2018; Valenzuela, 2012) erwiesen haben. Um die Ressourcen der nicht gehfähigen BewohnerInnen zu adressieren, wurden die recherchierten Übungen zum Teil für die Durchführung in sitzender Position modifiziert. Ein Auszug aus dem Multikomponenten-Trainingsprogramm mit Beispielübungen lässt sich aus Publikation 5 im Anhang entnehmen.

Im Rahmen dieser Dissertation wurde somit ein innovatives Trainingsprogramm entwickelt und auf die Bedürfnisse und Ressourcen von nicht Gehfähigen angepasst sowie auf Machbarkeit und Wirksamkeit untersucht, um die Forschungslücke zu schließen und den Teufelskreis zu unterbrechen. BewohnerInnen die in ihrer Mobilität stark eingeschränkt und auf einen Rollstuhl angewiesen sind, wurden in dieser Dissertation nicht wie in der bisherigen Forschung ausgeschlossen, sondern gezielt mit einer CBE Intervention adressiert. Aus den Ergebnissen können trainingswissenschaftliche Empfehlungen für eine CBE Intervention mit nicht gehfähigen BewohnerInnen in der stationären Altenpflege abgeleitet werden.

3 Forschungsfragen

Diese Dissertation widmet sich der Entwicklung und Bedarfsbestimmung (Publikation 1) eines Multikomponenten-Trainingsprogramms zur Förderung motorischer und kognitiver Ressourcen und des psychosozialen Wohlbefindens für nicht gehfähige BewohnerInnen in der stationären Altenpflege. Zeitlich parallel zur Entwicklung des Trainingsprogramms wurde eine systematische Übersichtsarbeit zur Evidenz von CBE durchgeführt (Publikation 2). Es folgten die Untersuchung der Machbarkeit (Publikation 3 + 4) sowie der Wirksamkeit der Trainingsintervention (Publikation 5). Ziel ist es, durch die Intervention einen weiteren Rückgang der funktionellen motorischen und kognitiven Leistung zu verlangsamen und die Unabhängigkeit bei Alltagsaktivitäten zu verbessern, um zu einem gesteigerten Wohlbefinden und einer höheren Lebensqualität beizutragen.

Zusammenfassend bietet die Dissertation einen konkreten Lösungsansatz zur Förderung einer besonders vulnerablen Zielgruppe und trägt dadurch zur Schließung der konzeptionellen Versorgungslücke in der stationären Altenpflege bei. Darüber hinaus leistet die Dissertation einen wertvollen Forschungsbeitrag zu den bisher unzureichend untersuchten nicht gehfähigen BewohnerInnen.

Die zentralen Fragestellungen, die diesen Forschungsprozess begleitet haben, sind:

1. Wie gestaltet sich eine Trainingsintervention zur Förderung motorischer, kognitiver und psychosozialer Ressourcen basierend auf den Bedürfnissen und Ressourcen von BewohnerInnen in Pflegeeinrichtungen? (Publikation 1)
2. Welche Evidenz haben CBE Interventionen zur Verbesserung motorischer und kognitiver Ressourcen sowie des psychosozialen Wohlbefindens für BewohnerInnen in Pflegeeinrichtungen? (Publikation 2)
3. Ist eine Multikomponenten-Trainingsintervention zur Förderung motorischer, kognitiver und psychosozialer Ressourcen im Setting Altenpflege mit einer ausreichenden Akzeptanz und Adhärenz der BewohnerInnen sowie einer guten Umsetzbarkeit des Trainings machbar? (Publikation 3 + 4)
4. Kann eine Multikomponenten-Trainingsintervention motorische und kognitive Ressourcen sowie das psychosoziale Wohlbefindens von nicht gehfähigen BewohnerInnen in der stationären Altenpflege erhalten oder verbessern? (Publikation 5)

Die zugehörigen Publikationen dieser kumulierten Dissertationsschrift beschreiben den Forschungsprozess zur Annäherung an die Forschungsfragen.

4 Studien im Rahmen der vorliegenden Dissertation

4.1 Publikation 1 – Bedarfsbestimmung und Entwicklung einer Multikomponenten-Trainingsintervention in der stationären Altenpflege

Cordes, T., Bischoff, L. L., Schoene, D., Schott, N., Voelcker-Rehage, C., Meixner, C., Appelles, L. M., Bebenek, M., Berwinkel, A., Hildebrand, C., Jöllenbeck, T., Johnen, B., Kemmler, W., Klotzbier, T., Korbus, H., Rudisch, J., Vogt, L., Weigelt, M., Wittelsberger, R., Zwingmann, K., … Wollesen, B. (2019). A multicomponent exercise intervention to improve physical functioning, cognition and psychosocial well-being in elderly nursing home residents: a study protocol of a randomized controlled trial in the PROCARE (prevention and occupational health in long-term care) project. *BMC Geriatrics, 19*(1), 369. https://doi.org/10.1186/s12877-019-1386-6 (IF: 3.927)

4.1.1 Die Bedarfsbestimmung

Ziel dieser Publikation war die Bedarfsbestimmung und die Entwicklung einer Multikomponenten-Trainingsintervention in der stationären Altenpflege. Im ersten Schritt wurden zur Bedarfsbestimmung qualitative Interviews mit fünf BewohnerInnen (vier Frauen und ein Mann) in der Einrichtung durchgeführt. Die Interviews dauerten durchschnittlich 18 Minuten und umfassten insgesamt 17 Fragen, in denen vier Hauptbereiche bewertet wurden: (I) Aktivitäten des Bewohners im täglichen Leben, (II) Unterstützungsbedarf, (III) Teilnahme an sozialen Aktivitäten sowie (IV) ihre Erwartungen und Wünsche in Bezug auf ein Trainingsprogramm. Der Tagesablauf der Befragten umfasste das Hören von Musik und Hörbüchern, Stricken, Zeichnen und Spazierengehen. Darüber hinaus wurde über den aktuellen Bedarf an Unterstützung im Alltag, etwa beim Anziehen, Duschen und Bewegung, berichtet. Drei BewohnerInnen äußerten sich unzufrieden über unerwünschte Abhängigkeiten und den Versuch, Aktivitäten wie persönliche Hygiene so autonom wie möglich durchzuführen. Soziale Kontakte und Aktivitäten wurden hauptsächlich durch Gruppenaktivitäten (Gottesdienst in der Einrichtung, Gesang und Stuhlgymnastik) realisiert. Darüber hinaus zeigten die Befragten großes Interesse an Musik und an spielerischen, gruppenbasierten Übungen. Zusammenfassend waren der Wunsch nach mehr sozialen Kontakten und GesprächspartnerInnen und die Notwendigkeit nach mehr Unabhängigkeit bei ADL Hauptthemen während der Interviews.

4.1.2 Die Entwicklung der Trainingsprogramme

Auf Basis der Ergebnisse aus der Bedarfsbestimmung wurden im nächsten Schritt zwei Multikomponenten-Trainingsprogramme speziell für die Anforderungen und Bedürfnisse von BewohnerInnen in der stationären Altenpflege entwickelt. Ein Programm wurde für die gehfähigen BewohnerInnen entwickelt und enthält verstärkt Übungen im Gehen und Stehen. Ein weiteres CBE Trainingsprogramm wurde für nicht gehfähige BewohnerInnen entwickelt, welches ausschließlich in sitzender Position durchgeführt werden kann.

Die Trainingsprogramme basieren neben den Ergebnissen der Interviews auf einer umfassenden Literaturrecherche zu Multikomponenten-Trainingsprogrammen und den Ergebnissen aus einer systematischen Übersichtsarbeit zu CBE (Publikation 2). Zudem wurde sich bei der Entwicklung an den Empfehlungen der IAGG-GARN (de Souto Barreto et al., 2016) und des American College of Sports Science (Chodzko-Zajko et al., 2009) für ein Training mit älteren Menschen orientiert. Die konkrete Übungsauswahl geschah mithilfe bereits veröffentlichter Übungen, die sich bei älteren Erwachsenen in der Gemeinde als vorteilhaft für den Erhalt motorischer und kognitiver Funktionen erwiesen haben (Fiatarone et al., 1990; Littbrand et al., 2009; Liu & Latham, 2009; Sherrington et al., 2008; de Souto Barreto et al., 2016; Thomas et al., 2010; Wollesen et al., 2017; Wollesen et al., 2017; Wollesen & Voelcker-Rehage, 2014).

Das Training bestand aus 32 Einheiten, die über einen Zeitraum von 16 Wochen durchgeführt wurden. Eine Trainingseinheit dauerte 45-60 Minuten und fand zweimal pro Woche statt. Das Programm für die Gehfähigen konzentrierte sich auf Situationen des Alltags der BewohnerInnen, die üblicherweise mit einem erhöhten Sturzrisiko verbunden sind. Daher wurden Übungen wie Starten, Stoppen, Bewältigen von Hindernissen, Drehen und zügiges Gehen sowohl unter Einfachen- als auch unter Doppelaufgabenbedingungen trainiert. Übungen für dynamisches Gleichgewicht, Ausdauer und Kraft waren ebenfalls ein wesentlicher Bestandteil des Trainings. Um den Wünschen aus den Interviews mit der Zielgruppe gerecht zu werden, integrierte das Training Musik sowie spielerische und motivierende Geräte (z. B. Bälle, Luftballons, Schals und Schwungtuch). Weitere Kleingeräte wie Gymnastikstäbe und Alltagsgegenstände wurden verwendet, um die Übungen alltagsnah und aufgabenspezifisch zu gestalten. Zusatzgewichte kamen zum Einsatz, um im Sinne einer progressiven Belastungssteigerung die Intensität erhöhen zu können.

Um eine überprüfbare Struktur zu erhalten, wurde das Programm wie folgt aufgebaut:

1. Mobilisation und Aufwärmen (ca. 5-10 min)

2. Koordination/Kognition inkl. Spielformen/Bewegungsgeschichten (ca. 8-10 min)

3. Gangbahnen: Gangstabilität, Ausdauer, Doppelaufgaben und Sturzprävention (ca. 15-25 min abhängig von Gruppengröße)

4. Kräftigung (5-10 min)

5. Auslockerung/Dehnen + Abschluss (ca. 5-10 min)

Im CBE Programm für die nicht gehfähigen BewohnerInnen wurden die Gangbahnen durch alternative ADL Übungen ersetzt und die Komponenten Kraft, Ausdauer, Beweglichkeit und Koordination ausschließlich in sitzender Position trainiert. Fokussiert wurde die Alltagsmotorik in Kombination mit Spielformen und Bewegungsgeschichten zur Förderung von Kognition und psychosozialen Ressourcen. Übungen mit Doppelaufgaben wurden ebenfalls für die Durchführung im Sitzen modifiziert. Ein Multikomponenten-Training mit einer Kombination aus Doppelaufgaben und CBE ist bisher nicht untersucht worden. Mit der Überprüfung der Machbarkeit und Wirksamkeit dieses innovativen Trainingsprogramms wurde daher eine konzeptionelle Forschungslücke geschlossen. Zudem stellen die Ergebnisse einen besonderen Mehrwert für die in der Forschung wenig berücksichtigten, nicht gehfähigen BewohnerInnen dar, indem sie die bestehenden allgemeinen Trainingsempfehlungen für Pflegebedürftige entscheidend ergänzen.

In einem weiteren Schritt des Forschungsprozesses wurde eine systematische Übersichtsarbeit zur Evidenz von CBE (Publikation 2) durchgeführt.

4.2 Publikation 2 – Systematische Übersichtsarbeit zur Evidenz von CBE in der Altenpflege

Cordes, T., Schoene, D., Kemmler, W. & Wollesen, B. (2021). Chair-Based Exercise Interventions for Nursing Home Residents: A Systematic Review. *Journal of the American Medical Directors Association, 22*(4), 733–740. https://doi.org/10.1016/j.jamda.2020.09.042 (IF: 4.669)

Parallel zur Entwicklung des Trainingsprogramms wurde eine systematische Übersichtsarbeit verfasst, um die aktuelle Evidenz zu CBE Interventionen im Setting Altenpflege zusammenzufassen. Nach bisherigem Kenntnisstand wurde bisher keine systematische Übersichtsarbeit über die Auswirkungen von CBE bei BewohnerInnen in der Altenpflege veröffentlicht. Eine Übersichtsarbeit zu CBE Interventionen für ältere Menschen, unabhängig ihres Mobilitätsstatus, berichtet zwar von positiven Effekten auf die Mobilität, Stabilität und Wohlbefinden, allerdings auch von niedriger Evidenz aufgrund einer schlechten Studienqualität (Anthony et al., 2013). Zudem wurden hier auch Trainingsprogramme eingeschlossen, die Übungen im Stehen enthielten, da kein Konsens über die Grundprinzipien von CBE besteht (Robinson et al., 2016). Es bleibt offen, inwiefern die Empfehlungen auch auf nicht gehfähige BewohnerInnen in der Altenpflege übertragbar sind.

Zu einem ähnlichen Ergebnis kam auch die Übersichtsarbeit dieser Dissertation. Hier zeigen die Ergebnisse, dass ein CBE Trainingsprogramm die physische und kognitive Funktionsfähigkeit und das Wohlbefinden von AltenpflegeheimbewohnerInnen verbessern oder erhalten kann. Allerdings fehlen bei einem Großteil der Studien konkrete Angaben zur Belastungssteuerung oder die Belastungsnormative variieren sehr stark, sodass sich hinsichtlich trainingswissenschaftlicher Aspekte nur wenige Empfehlungen aus der Übersichtsarbeit generieren lassen. Erfolgreiche Interventionen berichten über eine Frequenz von zwei bis fünf Mal pro Woche, einer Dauer von 30 bis 60 Minuten pro Trainingseinheit, für sechs Wochen bis sechs Monate Interventionszeit. Ein aufgabenspezifisches Multikomponenten-Training mit moderater Intensität erwies sich dabei als am besten geeignet. Dies steht im Einklang mit den Empfehlungen des Taskforce-Berichts der IAGG-GARN, die ebenfalls ein Multikomponenten-Training mit moderater Intensität und einer Belastungsdauer von 35-45 Minuten sowie einer Belastungsfrequenz von zweimal pro Woche empfehlen (de Souto Barreto et al., 2016).

Die zentralen Ergebnisse aus der systematischen Übersichtsarbeit lassen sich wie folgt zusammenfassen:

- Ein CBE Trainingsprogramm kann physische und kognitive Funktionen sowie das Wohlbefinden von AltenpflegeheimbewohnerInnen verbessern oder erhalten
- Die Studienqualität ist oft gering und es fehlen konkrete Angaben zur Belastungssteuerung
- Belastungsnormative variieren stark. Interventionen mit einer Frequenz von 2-5 Mal pro Woche, eine Dauer von 30-60 Minuten über einen Zeitraum zwischen 6 Wochen und 6 Monaten waren erfolgreich
- Ein Multikomponenten-Training erwies sich als eine geeignete Form des Trainings.

Die Ergebnisse können zwar die bestehenden Empfehlungen für ein Trainingsprogramm für BewohnerInnen in der Altenpflege leicht ergänzen, jedoch schränkt auch hier die fehlende Trennung von mobilen und nicht gehfähigen BewohnerInnen in den Analysen die Spezifität dessen ein, was konkret für diese Zielgruppe empfohlen werden kann. Diese Forschungslücke wurde bereits umfangreich erläutert und konnte auch mit dieser Übersichtsarbeit nicht geschlossen werden. Dennoch lassen sich aus der Zusammenfassung des aktuellen Forschungsstandes einige Empfehlungen zu Trainingsform und Belastungssteuerung bei CBE ableiten, die zumindest ein Stück zur Schließung der Lücke beitragen können. Aufgrund der insgesamt nur mäßigen Studienqualität und der oft kleinen Stichproben sind weitere randomisiert kontrollierte Studien mit größeren Stichproben dringend erforderlich. Diese sollten sich gezielt auf CBE für nicht Gehfähige fokussieren oder die Analysen nach Mobilitätsstatus trennen, um bedarfsgerechte Empfehlungen bereitstellen zu können. Eine solche Trennung nach Mobilitätsstatus wurde auch bei der Entwicklung der Trainingsprogramme in diesem Forschungsprojekt berücksichtigt. Im nächsten Schritt folgte eine Analyse beider Trainingsprogramme hinsichtlich der Machbarkeit (Publikation 3 + 4) bevor das CBE Training im Rahmen einer Wirksamkeitsanalyse (Publikation 5) untersucht wurde.

4.3 Publikation 3 – Machbarkeit einer Multikomponenten-Trainingsintervention im Setting Altenpflege

Bischoff, L. L., Cordes, T., Meixner, C., Schoene, D., Voelcker-Rehage, C., & Wollesen, B. (2020). Can cognitive-motor training improve physical functioning and psychosocial wellbeing in nursing home residents? A randomized controlled feasibility study as part of the PROCARE project. *Aging clinical and experimental research*, 10.1007/s40520-020-01615-y. Advance online publication. https://doi.org/10.1007/s40520-020-01615-y (IF: 3.636)

Um der Frage nach der Machbarkeit der Trainingsprogramme auf den Grund zu gehen, wurde zunächst das Trainingsprogramm für die gehfähigen BewohnerInnen überprüft und eine randomisiert kontrollierte Machbarkeitsstudie mit N=24 BewohnerInnen (83,7 ± 6,4, 21 weiblich) in einer stationären Altenpflegeeinrichtung in Hamburg durchgeführt. Ziel war es, dass neu entwickelte Trainingsprogramm auf seine Machbarkeit und hinsichtlich einer Verbesserung von motorischer Fitness, Kognition und Wohlbefinden zu überprüfen und zu evaluieren.

Insgesamt wurde das Multikomponenten-Trainingsprogramm gut akzeptiert und erwies sich durch den Einsatz verschiedener motorischer Komponenten als eine sinnvolle Trainingsform, um die BewohnerInnen in ihren Ressourcen zu stärken. Dies deckt sich mit den Empfehlungen aus dem Bericht der IAGG-GARN (de Souto Barreto et al., 2016). Motorische Funktionen in den unteren Extremitäten sowie die Handkraft der dominanten Hand konnten bei der Trainingsgruppe gesteigert werden, während die Kontrollgruppe abbaute. Hinsichtlich des psychosozialen Wohlbefindens ergaben sich keine Veränderungen. Die Lebenszufriedenheit konnte in der Trainingsgruppe leicht gesteigert werden. Die Selbstständigkeit in den ADL hat sich in beiden Gruppen nicht signifikant verschlechtert. Es konnten zwar keine signifikanten Veränderungen erzielt werden und dennoch kann ein Erhalt der Ressourcen als Erfolg gewertet werden, da die Funktionen üblicherweise einem natürlichen Abbau ausgesetzt sind (Masciocchi et al., 2019), der in der Trainingsgruppe ausblieb.

Für eine gute Adhärenz spricht die Teilnahmequote von durchschnittlich 75%. Die Belastungsdauer von 45-60 Minuten Training und die Frequenz an zwei nicht aufeinanderfolgenden Tagen pro Woche war gut machbar und wurde von den TeilnehmerInnen ebenfalls gut angenommen. Es kam zu keinen unerwünschten Nebenwirkungen, wie Stürzen oder Verschlechterungen der gesundheitlichen Situation, die auf die Intervention zurückzuführen wären. Das Trainingsprogramm musste jedoch in verschiedenen Punkten angepasst werden. Der Belastungsumfang erwies sich für einen Großteil der BewohnerInnen als zu hoch. So konnten viele aufgrund motorischer Defizite in Kraft und Ausdauer die im Trainingsprogramm vorgesehenen Gangstrecken nicht bewältigen. Die Gangstrecken wurden verkürzt und die Pausenzeiten zwischen den Sätzen erhöht. Auch ein unmittelbares Aufeinanderfolgen von Ausdauer und Kraftübungen erwies sich als eine zu hohe Belastungsintensität. Somit wurden zur besseren Regeneration der Beinmuskulatur nach der Ausdauerleistung, die Oberkörperkraftübungen im Sitzen statt wie geplant im Stehen durchgeführt. Weiter erwiesen sich die kognitiv-motorischen Übungen für die Mehrzahl der BewohnerInnen als zu komplex, aufgrund fortgeschrittener kognitiver Defizite. So wurden Übungen dahingehend modifiziert, dass beispielsweise die Dual-Task Aufgabe Rückwärtszählen während des Gehens nicht in 7er, sondern in 1er Schritten erfolgte. Die beschriebenen Anpassungen während des Interventionsprozesses waren hilfreich, um die Akzeptanz bei den TeilnehmerInnen zu erlangen und sie auf ihrem passenden Leistungsniveau abzuholen.

Die zentralen Ergebnisse der Machbarkeitsstudie lassen sich wie folgt zusammenfassen:

- Gute Akzeptanz des Multikomponenten-Trainingsprogramms
- Motorische Funktionen in den unteren Extremitäten sowie die Handkraft hat sich bei den TeilnehmerInnen der Trainingsgruppe verbessert
- Die Lebenszufriedenheit konnte in der Trainingsgruppe leicht gesteigert werden
- Belastungsumfang und Belastungsintensität mussten reduziert werden, um sich dem Leistungsniveau anzunähern
- Kognitiv-motorische Übungen waren zunächst zu komplex und wurden vereinfacht.

Laut Berichten des Pflegepersonals waren einige BewohnerInnen zum Zeitpunkt der Postmessungen nicht abkömmlich oder mental nicht bereit, das recht umfangreiche Messprotokoll vollständig zu absolvieren. Aufgrund der dadurch entstandenen recht kleinen Stichprobe lässt sich aus den Ergebnissen zur Wirksamkeit nur vorsichtig eine positive Richtung interpretieren. Weitere Forschung sollte das Trainingsprogramm für die Gehfähigen mit Rücksicht auf die diskutierten Einschränkungen und Schwierigkeiten anpassen. Diese neue Version sollte dann mit einer angemessenen Stichprobengröße auf ihre Wirksamkeit hinsichtlich einer Verbesserung der körperlichen und kognitiven Funktionsfähigkeit und des psychosozialen Wohlbefindens untersucht werden. Eine solche Studie wurde im Rahmen des PROCARE Projekts durchgeführt, ist aber nicht Teil dieser Dissertation, die sich mit der Wirksamkeit des Trainingsprogramms für nicht Gehfähige befasst hat. Auf Basis der gewonnenen Erkenntnisse zur Belastungssteuerung wurde auch das Training für die nicht Gehfähigen modifiziert bevor es im folgenden Schritt ebenfalls in einer Machbarkeitsstudie (Publikation 4) untersucht wurde.

4.4 Publikation 4 – Machbarkeit einer CBE Intervention für die Alltagsfunktionalität bei nicht gehfähigen BewohnerInnen

Cordes, T., & Wollesen, B. (2020). Bewegungsinterventionen zur Förderung der Alltagsfunktionalität für nicht gehfähige BewohnerInnen in der stationären Altenpflege. In: Wollesen, B., Meixner, C., Gräf, J., Pahmeier, I., Vogt, L., & Woll, A. (Hrsg.), Interdisziplinäre Forschung und Gesundheitsförderung in Lebenswelten. Bewegung fördern, vernetzen, nachhaltig gestalten (1. Aufl., S. 86-91). Hamburg, Deutschland: *Feldhaus* (Schriften der Deutschen Vereinigung für Sportwissenschaft, 289)

Ziel der Machbarkeitsstudie war es zu untersuchen, ob und wie eine CBE Intervention für nicht gehfähige BewohnerInnen in der stationären Altenpflege durchführbar ist und ob dadurch eine Verbesserung der Alltagsfunktionalität sowie eine Steigerung der Lebenszufriedenheit und des Wohlbefindens erreicht werden kann. Die Machbarkeitsstudie zum Trainingsprogramm für die Gehfähigen (Publikation 3) lieferte bereits hilfreiche Evaluationsergebnisse. Dahingehend wurde auch das Trainingsprogramm für die nicht Gehfähigen modifiziert und weiterentwickelt, um die Bedürfnisse und Ressourcen der BewohnerInnen noch gezielter zu adressieren. Diese Änderungen bestanden im Wesentlichen aus einer Vereinfachung der kognitiv-motorischen Übungen, die sich für die meisten TeilnehmerInnen mit schon leichten bis mittleren kognitiven Einschränkungen als zu komplex herausstellten. Zudem wurde die Belastungsintensität und die Belastungsdauer bei den Kraftübungen leicht reduziert und die Belastungsdichte verringert, indem die Pausenzeiten innerhalb einer Trainingseinheit ausgedehnt wurden. Das modifizierte CBE Trainingsprogramm wurde im Rahmen einer weiteren Machbarkeitsstudie im Prä-Post Design mit N=7 nicht gehfähigen BewohnerInnen in einer Altenpflegeeinrichtung durchgeführt und auf Veränderungen in der Alltagsfunktionalität untersucht.

Studien zu Trainingsinterventionen mit Kraft-, Beweglichkeits- und Gleichgewichtsübungen in der Gruppe zeigen positive Effekte auf die Alltagsfunktionalität von BewohnerInnen im Altenpflegeheim (Crocker et al., 2013). Allerdings bleibt unklar, wie die Trainingsinterventionen konkret inhaltlich strukturiert sein sollten, um neben der Alltagsfunktionalität, die Lebenszufriedenheit und das psychosoziale Wohlbefinden zu verbessern. Wie bereits beschrieben, zielen die meisten Interventionen auf die Förderung von noch gehfähigen BewohnerInnen ab, obwohl für diese besonders der Erhalt der Alltagsfunktionalität relevant ist (Schaeffer et al., 2016).

Ziel der Machbarkeitsstudie war es daher eine CBE Intervention gezielt für nicht gehfähige BewohnerInnen in der stationären Altenpflege auf ihre Durchführbarkeit zu überprüfen und herauszufinden, ob dadurch eine Verbesserung der Alltagsfunktionalität sowie eine Steigerung der Lebenszufriedenheit und des Wohlbefindens erzielt werden kann. Es wurde angenommen, dass ein Training noch bestehender motorischer Funktionen, wie Handkraft und das dynamische Gleichgewicht im Sitzen, die Alltagsfunktionalität erhalten oder verbessern und somit zu einer gesteigerten Lebenszufriedenheit beitragen kann.

Die Ergebnisse zeigen, dass die InterventionsteilnehmerInnen ihre Handkraft erhöhten und das dynamische Gleichgewicht im Sitzen im Verlauf von 16 Wochen steigern konnten. Ohne reguläres Training wäre in diesem Setting mit einer stetigen Abnahme von Handkraft und Gleichgewicht zu rechnen gewesen (Masciocchi et al., 2019). Das physische Wohlbefinden hat sich von Beginn der Studie bis zur Abschlussmessung nach 16 Wochen ebenfalls verbessert, während das psychische Wohlbefinden und die Lebenszufriedenheit stabil blieben. Obwohl hier keine Verbesserung festgestellt wurde, ist selbst der Erhalt bei dieser multimorbiden Zielgruppe als Erfolg zu werten, da auch die psychosozialen Funktionen in der Altenpflege durch eine stetige Abnahme gekennzeichnet sind (Scheidt-Nave et al., 2010). Die Stabilisierung der gesundheitlichen Situation und die Verhinderung einer Abwärtsentwicklung stehen hierbei im Vordergrund (Schaeffer & Büscher, 2009). Um motorische und psychosoziale Ressourcen von nicht gehfähigen BewohnerInnen zu erhalten, erwies sich das CBE Trainingsprogramm als geeignet und gut durchführbar. Dies entspricht auch der Wahrnehmung durch die betreuenden Pflegekräfte, die die Fähigkeiten der BewohnerInnen für die Ausübung von ADL als stabil beschrieben. Alle TeilnehmerInnen nahmen regelmäßig an der Intervention teil, was für eine hohe Akzeptanz spricht. Die Belastungssteuerung erwies sich ebenfalls als gut durchführbar. Hier wurde durch eine progressive Steigerung der Intensität ein trainingswirksamer Reiz gesetzt und ein erwarteter Zuwachs der Komponenten Kraft und Gleichgewicht erzielt. Diese Steigerung steht in direktem Zusammenhang mit einer verbesserten physischen Funktionsfähigkeit bezogen auf die ADL (Covinsky et al., 2003) und wirkt sich somit positiv auf die Lebenszufriedenheit und das Wohlbefinden aus (Kehyayan et al., 2016).

Die Ergebnisse der Machbarkeitsstudie für das CBE Trainingsprogramm lassen sich wie folgt zusammenfassen:

- Das CBE Trainingsprogramm erwies sich als machbar und wurde von den BewohnerInnen gut akzeptiert
- Handkraft und das dynamische Gleichgewicht im Sitzen haben sich nach 16 Wochen Training verbessert
- Das physische Wohlbefinden konnte gesteigert werden, während das psychische Wohlbefinden stabil blieb
- Die betreuenden Pflegekräfte beschreiben die Fähigkeiten für ADL bei den teilnehmenden BewohnerInnen als stabil
- Eine progressive Belastungssteuerung erwies sich als gut durchführbar.

Die Forschungsfrage zur Machbarkeit konnte somit für beide Trainingsprogramme positiv beantwortet werden (Publikation 3 + 4). Die Stichprobe war jedoch gering und das Prä-Post Studiendesign gibt lediglich Hinweise auf mögliche positive Effekte. Um valide Aussagen zur Wirksamkeit machen zu können, bedarf es einer randomisiert kontrollierten Wirksamkeitsstudie, die im Forschungsprozess als nächstes folgte (Publikation 5).

4.5 Publikation 5 – Multikomponenten-Training zur Verbesserung von Motorik, Kognition und Wohlbefinden bei nicht gehfähigen BewohnerInnen in der Altenpflege

Cordes, T., Zwingmann, K., Rudisch, J., Voelcker-Rehage, C. & Wollesen, B. (2021). Multicomponent exercise to improve motor functions, cognition and well-being for nursing home residents who are unable to walk – A randomized controlled trial. *Experimental Gerontology, 153,* 111484. https://doi.org/10.1016/j.exger.2021.111484 (IF: 4.032)

Zentraler Bestandteil dieser Forschungsarbeit ist die Wirksamkeitsanalyse der Multikomponenten-Trainingsintervention für nicht gehfähige BewohnerInnen mittels einer zweiarmigen, einfach verblindeten, randomisiert, kontrollierten Studie mit dem Ziel herauszufinden, ob motorische, kognitive und psychosoziale Ressourcen verbessert oder erhalten werden können. Hierfür wurden *N*=52 BewohnerInnen mit einem Durchschnittsalter von 81 Jahren (SD±11, Altersspanne 70 bis 92 Jahre, 63% weiblich) aus vier stationären Altenpflegeeinrichtungen in Bremen und Chemnitz rekrutiert und im Anschluss in eine Interventionsgruppe (sofortiger Start mit dem Training) und eine Wartelisten-Kontrollgruppe (Trainingsstart nach 16 Wochen) per Losverfahren randomisiert zugeteilt.

Das untersuchte Multikomponenten-Trainingsprogramm verbesserte erfolgreich die motorischen (Handkraft, Feinmotorik, Selbstständigkeit, Gleichgewicht) und kognitiven (kognitiver Status, Arbeitsgedächtnis) Funktionen und stabilisierte die psychosozialen Ressourcen (Wohlbefinden, Lebenszufriedenheit, Depressionsgrad) von nicht gehfähigen BewohnerInnen, während sich die Kontrollgruppe im Verlauf der 16 Wochen ohne Training in allen untersuchten Parametern signifikant verschlechterte. Dies deckt sich mit den Erkenntnissen der Forschungsgruppe von Masciocchi et al. (2019), die einen progressiven Verlust von Handkraft (-2,2% pro Monat) und Gleichgewicht (-2,8% pro Monat) durch Inaktivität bei BewohnerInnen zeigen konnten. Dieser altersbedingte Rückgang durch Inaktivität (Jansen et al., 2017) könnte auch die Verschlechterung der motorischen Funktionen in unserer Kontrollgruppe erklären. Neben den Funktionsverlusten in der Motorik (Valenzuela et al., 2018) hat Inaktivität auch einen negativen Einfluss auf kognitive Funktionen (Northey et al., 2018), was sich ebenfalls bei der Kontrollgruppe in unserer Studie beobachten ließ. Auch psychosoziale Parameter verschlechtern sich typischerweise mit zunehmenden Alter bei AltenpflegeheimbewohnerInnen (Henskens et al., 2018; Scheidt-Nave et al., 2010). Daher kann das Ausbleiben einer Verschlechterung und die Stabilisierung des Wohlbefindens und der Lebenszufriedenheit in unserer Trainingsgruppe als Erfolg gewertet werden.

Ein Multikomponenten-Training, welches sich bei vielen Studien mit Gehfähigen als wirksam erwiesen hat (Arrieta et al., 2018; Forbes et al., 2015; Grönstedt et al., 2013; Johnen & Schott, 2018; Kryger & Andersen, 2007; Weening-Dijksterhuis et al., 2011; Yümin et al., 2011), kann unter Berücksichtigung einer trainingswissenschaftlichen Belastungssteuerung zu einem CBE Programm modifiziert und für den Einsatz bei nicht gehfähigen BewohnerInnen empfohlen werden.

Hinweise für eine geeignete Belastungssteuerung konnten in den Studien aus der Übersichtsarbeit zu CBE (Publikation 2) nur unzureichend gefunden werden. Die Umsetzung des Trainingsprogramms orientierte sich deshalb an trainingswissenschaftlichen Grundsätzen zu den Belastungsnormativen (Hottenrott, 2017) sowie an den allgemeinen Empfehlungen vom ACSM für ältere Menschen (Garber et al., 2011) und der IAGG-GARN für Pflegebedürftige (de Souto Barreto et al., 2016). Die Ergebnisse dieser Studie zeigen, dass eine Belastungsumfang von 60 Minuten pro Trainingseinheit, eine Frequenz von zweimal pro Woche an zwei nicht aufeinanderfolgenden Tagen, für einen Zeitraum von insgesamt vier Monaten als praktikabel und wirksame empfohlen werden können. Dies deckt sich mit den oben genannten Empfehlungen der ACSM und der IAGG-GARN. Im Setting Rehabilitation hat sich gezeigt, dass die Borg-Skala

(Borg, 1998) eine valide Methode zur Steuerung der Belastungsintensität darstellt, aber bei Personen mit kognitiven Einschränkungen mit Vorsicht anzuwenden ist (Stuckenschneider et al., 2020). Auch in unserer Studie erwies sich das Abfragen der wahrgenommenen Erschöpfung über die Borg Skala als geeignetes Mittel für die meisten BewohnerInnen. Mit dem Ziel einer moderaten Intensität wurde ein Skalenwert von 12 bis 14 angestrebt. Bei Abweichungen wurde die Intensität verringert oder im Sinne einer progressiven Belastungssteigerung regelmäßig erhöht, um einen optimalen und ausreichenden Trainingsreiz für eine metabolische Anpassung zu setzen. Dies geschah über eine Veränderung der Übungskomplexität, einer Erhöhung der Wiederholungs- und/oder Satzzahl, sowie durch Hinzunehmen zusätzlicher 1,5kg – 2kg Gewichte. Wie bei der Studie von Stuckenschneider et al. (2020) berichtet, gab es auch bei unserer Studie BewohnerInnen bei denen die Borg Skala aufgrund kognitiver Einschränkungen nicht adäquat verwendet werden konnte. Hier wurde der Grad der Erschöpfung anhand der Atemreaktion im Dialog während des Trainings geschätzt. Über die Schwierigkeit, die Intensität bei Trainingsinterventionen für Menschen mit kognitiven Einschränkungen zu kontrollieren, wurde auch in einer weiteren Studie berichtet (Pereira et al., 2018). Eine zusätzliche Kontrolle über andere Faktoren, wie beispielsweise die Herzfrequenz, könnte eine genauere Methode sein. Die Praktikabilität einer Belastungssteuerung über die Herzfrequenz im Setting Altenpflege sollte in zukünftigen Studien untersucht werden. In dieser Studie haben wir die Trainingsintensität auf moderat begrenzt. Frühere Studien mit gehfähigen, älteren Erwachsenen zeigten auch Wirksamkeit bei hochintensiven Geh- und Stehübungen (Conradsson et al., 2015; Littbrand et al., 2009; Rosendahl, 2006). Übungen mit höheren Intensitäten könnten auch für die Zielgruppe der nicht Gehfähigen als CBE machbar und wirksam sein. Allerdings besteht bei einem Training mit hohen Intensitäten und einer untrainierten Zielgruppe mit älteren Menschen ein gewisses Risiko für kardiovaskuläre Nebenwirkungen (Franklin et al., 2020) und sollte daher mit Vorsicht durchgeführt werden. Diese Überlegungen zeigen, dass eine gezielte Belastungssteuerung ein wichtiger Faktor bei Trainingsinterventionen ist und bei Studien mit multimorbiden BewohnerInnen in der Altenpflege mehr in den Fokus rücken sollte. Dieser Aspekt ist bisher unzureichend erforscht und könnte zur Erweiterung der Richtlinien für Trainingsinterventionen mit dieser Zielgruppe beitragen. Die Ergebnisse dieser Forschung liefern dazu bereits erste Anhaltspunkte, die es mithilfe weiterer Studien zu Dosis-Wirkung-Beziehungen auch bei einem Training mit nicht Gehfähigen zu bestätigen gilt.

Ein weiterer Aspekt in unserem Trainingsprogramm war der gezielte Einsatz von kognitiv-motorische Übungen, die bereits in Studien mit älteren Menschen in der Gemeinde (Wollesen & Voelcker-Rehage, 2014; Wollesen et al., 2020) und bei Menschen mit Demenz (Schwenk et al.,

2010) erfolgreich eingesetzt wurden. Solche kognitiv-motorischen Trainingsprogramme haben sich als machbar erwiesen und könnten den größten Einfluss auf die gleichzeitige Verbesserung der motorischen und kognitiven Funktionen haben (Levin et al., 2017). Die Ergebnisse unserer Studie zeigen, dass kognitiv-motorischen Übungen auch wirksam sein können, wenn sie zu CBE modifiziert und mit nicht gehfähigen BewohnerInnen durchgeführt werden. Viele ADL, wie das unabhängige Fahren und gleichzeitiges Orientieren mit dem Rollstuhl oder gleichzeitig eine Unterhaltung führen und sich dabei eine Tasse Tee einschenken, erfordern motorische und kognitive Leistung parallel und sind deshalb auch für nicht Gehfähige von hoher Relevanz. Im Rahmen der systematischen Literaturrecherche zu CBE (Publikation 2), konnte eine Studie identifiziert werden, die motorische Übungen in Kombination mit mentalen und Gedächtnisübungen in sitzender Position durchgeführt hat und damit die kognitiven Funktionen der BewohnerInnen verbessern konnte (Thurm et al., 2011). Eine vergleichbare Verbesserung der kognitiven Leistung wurde auch durch unsere Ergebnisse gezeigt. Eine andere kürzlich veröffentlichte Studie hat jedoch gezeigt, dass die Kombination aus kognitivem Training und Multikomponenten-Training dem einfachen Multikomponenten-Training nicht überlegen zu sein scheint (Rezola-Pardo et al., 2019). Die Anzahl der Studien mit Dual-Task Übungen im Rahmen eines CBE Programms sind selten. Studien die dabei gezielt die Wirksamkeit bei nicht gehfähigen BewohnerInnen beobachten sind nicht bekannt und sollten weiter erforscht werden, um das Potenzial von Dual-Task als CBE Programm zu untersuchen. Auch Dual-Task Aufgaben in Kombination mit Übungen der oberen Extremitäten sind machbar (Voelcker-Rehage & Alberts, 2007) und haben sich in dieser Studie als geeignet erwiesen.

Die zentralen Ergebnisse der Wirksamkeitsanalyse lassen sich wie folgt zusammenfassen:

- Trotz Mobilitätseinschränkungen verfügen nicht gehfähige BewohnerInnen über motorische, kognitive und psychosoziale Ressourcen, die durch ein bedarfsgerechtes Training gefördert werden können
- Die Multikomponenten-CBE Trainingsintervention kann motorische und kognitive Funktionen zur Förderung der Selbstständigkeit bei ADL verbessern
- Einer Verschlechterung des psychosozialen Wohlbefindens kann durch das CBE Programm gebremst werden
- Ein Multikomponenten-CBE Training mit kognitiv-motorischen Übungen ist machbar und kann unter Berücksichtigung einer progressiven, trainingswissenschaftlichen Belastungssteuerung für nicht gehfähige BewohnerInnen empfohlen werden

- Diese Studie trägt mit neuen Erkenntnissen und Trainingsempfehlungen dazu bei, die Auswirkungen von Multimorbidität und den fortschreitenden Funktionsverlust bei nicht gehfähigen PflegeheimbewohnerInnen zu reduzieren.

Die Ergebnisse liefern ein besseres Verständnis über Training mit nicht gehfähigen BewohnerInnen in der Altenpflege, ein Bereich, der in der Forschung bisher noch stark unterrepräsentiert ist. Ein Grund für diese Forschungslücke könnte die Angst vor Überlastung und Verletzungen sein, wenn dieselben Prinzipien für Übungen angewendet werden, die für gehfähige, ältere Erwachsene existieren. Ein weiterer Grund könnte die falsche Annahme sein, dass Trainingsinterventionen bei fortgeschrittener Gebrechlichkeit und Immobilität die motorischen Funktionen nicht mehr verbessern können (Ferrucci et al., 2004). Betreuungspersonal ohne sportwissenschaftlichen Hintergrund entscheidet sich aus Angst und/oder Unwissenheit eventuell lieber für leichte, wiederholende Bewegungsübungen ohne gezielte Belastungssteuerung, mit dem Ziel zumindest Spaß, soziale Teilhabe und ein Minimum an körperlicher Aktivität aufrechtzuerhalten. Die Ergebnisse dieser Studie zeigen jedoch, dass selbst institutionalisierte und gebrechliche BewohnerInnen in der Altenpflege, die nicht laufen können, durch ein Multikomponenten-Training die motorischen und kognitiven Ressourcen sowie das psychosoziale Wohlbefinden verbessern oder aufrechterhalten können. Dafür ist es nötig, die speziellen Ressourcen der nicht gehfähigen BewohnerInnen gezielt zu berücksichtigen, die Belastung adäquat zu steuern und das Trainingsprogramm auf diese Zielgruppe zuzuschneiden.

5 Diskussion

Ziel dieser Dissertation war die Entwicklung, Überprüfung der Machbarkeit und die Wirksamkeitsanalyse einer CBE Multikomponenten-Trainingsintervention zur Förderung motorischer und kognitiver Funktionen und des psychosozialen Wohlbefindens für nicht gehfähige BewohnerInnen in der stationären Altenpflege. Hierfür wurde der Forschungsprozess von zentralen Fragestellungen begleitet, wie der Frage nach einer bedarfsgerechten Gestaltung einer Trainingsintervention, die mit einer ausreichenden Akzeptanz und Adhärenz der BewohnerInnen machbar ist. Eine weitere zentrale Fragestellung beschäftigt sich mit der Evidenz von CBE Interventionen im Setting der stationären Altenpflege. Darauf aufbauend widmet sich die Dissertation der Beantwortung der Frage nach der Wirksamkeit einer CBE Multikomponenten-Trainingsintervention zur Förderung motorischer und kognitiver Ressourcen sowie des psychosozialen Wohlbefindens von nicht gehfähigen BewohnerInnen.

Die zentralen Ergebnisse dieser Dissertation zeigen, dass ein Multikomponenten-Training durchgeführt als CBE Programm eine praktikable und wirksame Intervention speziell für die Förderung motorischer, kognitiver und psychosozialer Ressourcen bei stark mobilitätseingeschränkten, nicht mehr gehfähigen BewohnerInnen darstellt. Weiter zeigen die Ergebnisse, dass der stetige körperliche Abbau durch Inaktivität (Masciocchi et al., 2019) sowie die damit verbundene erhöhte Gebrechlichkeit, eine verminderte kognitive Leistungsfähigkeit (Furtado et al., 2020) und ein vermindertes Wohlbefinden (Crocker et al., 2019), auch bei nicht gehfähigen BewohnerInnen durch eine bedarfsgerechte Intervention verlangsamt werden kann.

Um diese positiven Wirkungen zu erzielen wurde die Intervention so konzipiert, dass besonders BewohnerInnen mit geringer Mobilität die häufig in ihrer sozialen Teilhabe eingeschränkt sind bedarfsgerecht adressiert werden. Die durch eine solche Intervention gesteigerte Möglichkeit zur sozialen Teilhabe hat einen wesentlichen Einfluss auf eine höhere Lebenszufriedenheit (Kehyayan et al., 2016). Zudem weisen gebrechliche, ältere Menschen ein höheres allgemeines Wohlbefinden auf, wenn die soziale Teilhabe an Aktivitäten möglich ist (van der Vorst et al., 2017). Die Ergebnisse zum Wohlbefinden aus dieser Dissertation bestätigen diesen Zusammenhang. Hierbei konnten die psychosozialen Ressourcen, im Vergleich zum Abbau in der Kontrollgruppe, durch die Intervention stabil gehalten werden. Ein interessanter Aspekt für weiterführende Forschung zur Lebensqualität wäre in diesem Kontext der Vergleich einer CBE Multikomponenten-Trainingsintervention mit einer Intervention die aktive Teilhabe ohne körperliches Training fördert.

Die Wahl einer geeigneten Trainingsform und die Untersuchung einer optimalen Belastungssteuerung für ein Training mit multimorbiden, nicht gehfähigen BewohnerInnen war ebenfalls zentraler Bestandteil dieser Dissertation. Ein Multikomponenten-Training kombiniert mit kognitiv-motorischen Übungen wird als vielversprechende Möglichkeit zur Förderung motorischer und kognitiver Ressourcen bei älteren Menschen empfohlen (de Souto Barreto et al., 2016) und die Kombination aus motorischen und kognitiven Anforderungen im Sinne eines Dual-Task Trainings, stellt eine effektive Möglichkeit dar, um kognitive Ressourcen zu verbessern (Karssemeijer et al., 2017; Netz, 2019; Bettina Wollesen & Voelcker-Rehage, 2014; Bettina Wollesen, Wildbredt, et al., 2020). Ein solches Training wurde im Rahmen der Forschungsarbeit entwickelt, für die Durchführung im Sitzen modifiziert und hat sich als machbar und wirksam erwiesen. Kognitive (Arbeitsgedächtnis, kognitiver Status) und motorische Ressourcen (Handkraft, Gleichgewicht, Feinmotorik, Selbstständigkeit) konnten durch das Training verbessert werden. Diese Ergebnisse bestätigen zudem die Erkenntnisse aus anderen Studien die durch ein Multikomponenten-Training mit gehfähigen BewohnerInnen Verbesserungen motorischer Ressourcen (Handkraft, Gleichgewicht, Selbstständigkeit) (Arrieta et al., 2019; Grönstedt et al., 2013) erreichen konnten. Ein kognitiv-motorisches Training als CBE Programm bietet somit einen vielversprechenden Ansatz für eine gesundheitsfördernde Intervention im Setting Altenpflege. Die Ergebnisse aus der Machbarkeitsstudie dieser Dissertation bestätigen zwar die Praktikabilität eines solchen Trainings, zeigen allerdings auch Grenzen hinsichtlich des Schwierigkeitsgrades besonders für kognitive Übungen auf. Weitere Forschung sollte sich der Frage widmen, wie ein kognitiv-motorisches Training optimal an diese mobilitätseingeschränkte Zielgruppe mit zum Teil kognitiven Defiziten angepasst werden kann und welche Bedeutung der Anteil kognitiv-motorischer Übungen in dem CBE Multikomponenten-Training hat um motorische und kognitive Ressourcen zu fördern. Eine Studie die ein einfaches CBE Multikomponenten-Training mit einem CBE Multikomponenten-Training inklusive kognitiv-motorischen Übungen vergleicht, könnte Aufschluss darüber geben. Ein ähnliches Studiendesign wurde bereits mit gehfähigen BewohnerInnen durchgeführt und kam zu dem Ergebnis, dass eine Ergänzung durch kognitiv-motorische Übungen zwar wirksam ist, jedoch keinen zusätzlichen Vorteil für ein Multikomponenten-Training bringt um motorische und kognitive Ressourcen zu verbessern (Rezola-Pardo et al., 2019).

Eine optimale Belastungssteuerung ist besonders bei heterogenen Zielgruppen ein entscheidender Faktor, um Aussagen zu Dosis-Wirkungsbeziehungen treffen zu können (Herold et al., 2019). Dennoch ist dieser Aspekt in der Forschung zu CBE kaum berücksichtigt oder in Studien berichtet. Die bestehenden Trainingsempfehlungen zu den Belastungsnormativen Intensität, Häufigkeit und Dauer für mobile, ältere Menschen (de Souto Barreto et al., 2016), erwiesen sich als gut übertragbar auf die Anforderungen an ein Training mit nicht gehfähigen BewohnerInnen. Die Ergebnisse dieser Forschungsarbeit zeigen weiter, dass ein Training mit standardisierten Wiederholungszahlen trotz gängiger Praxis bei Interventionen mit älteren Menschen ungeeignet scheint (Bouchard & Rankinen, 2001). Es wird deutlich, dass es für Trainingsinterventionen zur Förderung für diese Zielgruppe keinen „one size fits all“ Ansatz gibt. Im Gegenteil kann bestätigt werden, dass die individuelle und bedarfsgerechte Anpassung der Belastungsintensität sowie deren Überwachung einen entscheidenden Faktor für den Trainingserfolg darstellt (Grönstedt et al., 2013; Pol et al., 2020; Zaleski et al., 2016).

Die aus dieser Dissertation gewonnen Erkenntnisse liefern zudem einen besonderen gesundheitspolitischen Mehrwert durch Empfehlungen zur Gesundheitsförderung multimorbider Pflegebedürftiger. Multimorbidität gilt als ein erheblicher Belastungsfaktor für das Gesundheitssystem (Puth et al., 2017). Somit stellt sich die vorliegende Forschungsarbeit einer der wichtigsten Herausforderungen in der Gesundheitsforschung (Puth et al., 2017) und leistet einen Beitrag zum Rahmenmodell der Multimorbidität von Scheidt-Nave et al. (2010), indem sie Pflege- und Betreuungspersonal, TrainerInnen, Sport- und GesundheitswissenschaftlerInnen, Krankenkassen sowie politische EntscheidungsträgerInnen dazu ermutigt, die multimorbide und stetig wachsende Gruppe der BewohnerInnen in der stationären Altenpflege in Bezug auf motorische Ressourcen weiter zu differenzieren und im bio-psychosozialen Kontext zu betrachten. Das Erkennen und Berücksichtigen von individuellen Bedürfnissen und Ressourcen sowie der Kontextfaktoren multimorbider Menschen spielt dabei eine zentrale Rolle.

6 Konsequenzen für zukünftige Forschungsprogramme

Die in dieser Dissertation diskutierten trainingswissenschaftlichen Erkenntnisse liefern bereits erste Lösungsansätze zur Schließung einer Forschungslücke, indem konkrete Hinweise und Empfehlungen für ein wirksames Training mit einer bisher kaum untersuchten Kohorte gegeben werden. Weitere Forschungen und Interventionen, die sich mit Dosis-Wirkung-Beziehungen und einer optimalen Belastungssteuerung beschäftigen, könnten ebenfalls zu einer Bestätigung der Ergebnisse dieser Dissertation führen und dadurch zu einer Erweiterung von Trainingsempfehlungen und Richtlinien für nicht gehfähige BewohnerInnen sowie zu einer Schließung der Forschungslücke beitragen.

Hierbei könnte die Frage nach der optimalen Belastungsintensität genauer untersucht werden. Die Belastungsintensität des erfolgreichen Trainingsprogramms dieser Dissertation kann als moderat eingestuft werden. Neuere Studien berichten jedoch auch den erfolgreichen Einsatz eines hoch-intensiven Trainings in der Altenpflege (Conradsson et al., 2015; Sondell et al., 2018). Zu hoch-intensivem CBE Training für nicht gehfähige BewohnerInnen sowie einem Vergleich zwischen moderater und hoch-intensiver Belastungsintensität bei der Zielgruppe, sind bisher keine Forschungsarbeiten bekannt. Zudem sollten sich weitere Untersuchungen mit der Frage der Wirksamkeit einer Multikomponenten-Trainingsintervention bei BewohnerInnen mit bereits fortgeschrittenen demenziellen Erkrankungen befassen. Erste Erkenntnisse mit Empfehlungen zur Umsetzbarkeit eines ähnlichen Trainingsprogramms bei BewohnerInnen mit demenziellen Erkrankungen wurden bereits veröffentlicht (Kruse et al., 2021).

Darüber hinaus bietet das Setting der Neurorehabilitation ein ähnlich vulnerables Patientenklientel im oft höheren Alter mit motorischen Einschränkungen in der Gehfähigkeit. Etwa 35% der Schlaganfallpatienten mit einer Paraparese der Beine verfügen nicht über eine ausreichende Funktion, um laufen zu können und benötigen einen Rollstuhl (Dobkin, 2005). Auch für diese Zielgruppe wäre die Anwendbarkeit und Wirksamkeit eines CBE Multikomponenten-Trainingsprogramms eine interessante Frage für zukünftige Forschungsarbeiten.

Der Einsatz von Musik, kognitiv-motorischen Spielformen und verschiedenen Trainingsmaterialien wie Hanteln, Stäbe und Bälle, erwies sich zudem als ein erfolgreicher, motivationaler Faktor des Trainings und trugen zu einer gesteigerten Akzeptanz bei. Weitere Forschungen sollten den Einsatz dieser und anderer motivationaler Faktoren gezielt bei BewohnerInnen in der stationären Altenpflege untersuchen, um somit die Adhärenz und eine nachhaltig hohe Teilnehmerquote erreichen zu können. Hierbei stellt der Einsatz von sogenannten Exergames (Exercise + Games) einen vielversprechenden, neuen Ansatz zur Steigerung der Trainingsmotivation für ein kognitiv-motorisches Training im Setting Geriatrie dar (Altorfer et al., 2021). Ebenso der Einsatz von körperlichen Fitnessübungen in Wettbewerbsform, erwies sich bei BewohnerInnen in der Altenpflege als machbar und wirksam zur Förderung der Motivation und motorischer Ressourcen wie Gleichgewicht und Kraft (Charles et al., 2020).

Für das Setting Altenpflege bietet diese Forschungsarbeit einen besonderen Mehrwert durch Erkenntnisse für die praktische Umsetzung eines gesundheitsförderlichen Trainings. Eine solche Übertragung von evidenzbasierten Praxisempfehlungen in das Setting der Pflegeeinrichtung hat international eine hohe Priorität für zukünftige Forschung in der Altenpflege (Morley et al., 2014).

Die durch diese Dissertation gewonnenen Erkenntnisse und der daraus resultierende Mehrwert für die Forschung lässt sich wie folgt zusammenfassen:

- Konkrete Hinweise und Empfehlungen für ein wirksames Training und eine adäquate Trainingssteuerung mit einer bisher kaum untersuchten Kohorte
- Erweiterung bestehender Empfehlungen und Richtlinien mit evidenzbasierten Empfehlungen zur praktischen Umsetzung und Machbarkeit eines CBE Trainings mit nicht gehfähigen BewohnerInnen
- Schließung sowohl einer Forschungslücke als auch einer Lücke in der Versorgung von nicht gehfähigen BewohnerInnen
- Unterbrechung des Teufelskreises aus Ressourcenabbau und verminderter, sozialer Teilhabe
- Förderung der höchstmöglichen Selbstständigkeit bei ADL für eine hohe Lebensqualität unabhängig vom Mobilitätsstatus.

In der Konzipierung von wirksamen Trainingsprogrammen zur Gesundheitsförderung und der Gewinnung evidenzbasierter Empfehlungen für die Versorgung liegt eine der wichtigsten Herausforderungen der zukünftigen Forschung (Horn et al., 2012). Diese Dissertation leistet dafür einen Beitrag und trägt nicht nur zu einer Schließung der Forschungslücke, sondern auch zur Schließung einer konzeptionellen Lücke in der Gesundheitsversorgung bei, die durch weitere Studien unterstützt werden sollte. Denn eine Schließung dieser Lücken verfolgt das Ziel einer universellen Prävention, die den Erhalt einer höchstmöglichen Selbstständigkeit bei der Durchführung von ADL durch das Ausbremsen eines funktionellen motorischen und kognitiven Abbaus fördert. Im Vordergrund steht dabei die Unterstützung einer aktiven Teilhabe für eine hohe Lebensqualität, unabhängig vom Mobilitätsstatus und bis ans Lebensende.

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Anhang

Anhang A: Publikationsübersicht und Eigenanteil an den Publikationen

Die vorliegende kumulative Dissertation basiert auf vier Publikationen (Publikation 1+2+4+5) bei denen der Autor dieser Dissertation in Erstautorenschaft das Erstmanuskript geschrieben hat. Bei einer weiteren Publikation im Rahmen dieser Dissertation (Publikation 3) fungierte der Autor dieser Dissertation in Zweitautorenschaft und hat einen wesentlichen Anteil der theoretischen Herleitung, Methodik, Ergebnisdarstellung und Diskussion mitverfasst und bei der kritischen Überarbeitung mitgewirkt. Bei allen Publikationen war der Autor dieser Dissertation zudem maßgeblich an der Ideenentwicklung beteiligt sowie für die Probandenakquise, Untersuchungsdurchführung, Datenerhebung und Analyse verantwortlich.

Tabelle 1A

Veröffentlichte Publikationen in Fachzeitschriften mit Impact-Faktor und Zitationen

Status	Publikationen in Fachzeitschriften mit Impact-Faktor
Veröffentlicht (Publikation 1 der kumulativen Dissertation)	**Cordes, T.**, Bischoff, L. L., Schoene, D., Schott, N., Voelcker-Rehage, C., Meixner, C., Appelles, L. M., Bebenek, M., Berwinkel, A., Hildebrand, C., Jöllenbeck, T., Johnen, B., Kemmler, W., Klotzbier, T., Korbus, H., Rudisch, J., Vogt, L., Weigelt, M., Wittelsberger, R., Zwingmann, K., … Wollesen, B. (2019). A multicomponent exercise intervention to improve physical functioning, cognition and psychosocial well-being in elderly nursing home residents: a study protocol of a randomized controlled trial in the PROCARE (prevention and occupational health in long-term care) project. *BMC Geriatrics, 19*(1), 369. https://doi.org/10.1186/s12877-019-1386-6
Veröffentlicht (Publikation 2 der kumulativen Dissertation)	**Cordes, T.,** Schoene, D., Kemmler, W. & Wollesen, B. (2021). Chair-Based Exercise Interventions for Nursing Home Residents: A Systematic Review. *Journal of the American Medical Directors Association, 22*(4), 733–740. https://doi.org/10.1016/j.jamda.2020.09.042
Veröffentlicht (Publikation 3 der kumulativen Dissertation)	Bischoff, L. L., **Cordes, T.**, Meixner, C., Schoene, D., Voelcker-Rehage, C., & Wollesen, B. (2020). Can cognitive-motor training improve physical functioning and psychosocial wellbeing in nursing home residents? A randomized controlled feasibility study as part of the PROCARE project. *Aging clinical and experimental research,* 10.1007/s40520-020-01615-y. Advance online publication. https://doi.org/10.1007/s40520-020-01615-y

Status	Publikationen in Fachzeitschriften mit Impact-Faktor
Veröffentlicht **(Publikation 5 der kumulativen Dissertation)**	**Cordes, T.,** Zwingmann, K., Rudisch, J., Voelcker-Rehage, C. & Wollesen, B. (2021). Multi-component exercise to improve motor functions, cognition and well-being for nursing home residents who are unable to walk – A randomized controlled trial. *Experimental Gerontology, 153,* 111484. https://doi.org/10.1016/j.exger.2021.111484
Veröffentlicht	Rudisch, J., Jöllenbeck, T., Vogt, L., **Cordes, T.**, Klotzbier, T. J., Vogel, O., & Wollesen, B. (2021). Agreement and consistency of five different clinical gait analysis systems in the assessment of spatiotemporal gait parameters. *Gait & Posture, 85, 55–64.* Advance online publication. https://doi.org/10.1016/j.gaitpost.2021.01.013
Veröffentlicht	Wollesen, B., Rudnik, S., Gulberti, A., **Cordes, T.,** Gerloff, C. & Poetter-Nerger, M. (2021). A feasibility study of dual-task strategy training to improve gait performance in patients with Parkinson's disease. *Scientific Reports, 11*(1). https://doi.org/10.1038/s41598-021-91858-0
Veröffentlicht	Klotzbier, T. J., Wollesen, B., Vogel, O., Rudisch, J., **Cordes, T.,** Jöllenbeck, T. & Vogt, L. (2021). An interrater reliability study of gait analysis systems with the dual task paradigm in healthy young and older adults. *European Review of Aging and Physical Activity, 18*(1). https://doi.org/10.1186/s11556-021-00271-z
Veröffentlicht	Kruse, A., **Cordes, T.,** Schulz, S. & Wollesen, B. (2021). Feasibility of Multicomponent Training for People with Moderate to Severe Dementia Living in a Long-Term Care Home: A Social Ethical Approach. *International Journal of Environmental Research and Public Health, 18*(14), 7631. https://doi.org/10.3390/ijerph18147631
In Planung **Einreichung Sep 2022**	Wollesen, B., Schott, N., Otto, A., **Cordes, T**., Rudisch, J., Vogel, O., Zwingmann, K., & Voelcker-Rehage, C. (2021). Are cognition and physical fitness predictors of mobility in nursing home residents in long-term care? - An observational study within the PROCARE-project. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences*

Tabelle 2A

Veröffentlichte Publikationen in Herausgeberschaften

Status	Publikationen in Herausgeberschaften
Veröffentlicht **(Publikation 4 der kumulativen Dissertation)**	**Cordes, T.**, & Wollesen, B. (2020). Bewegungsinterventionen zur Förderung der Alltagsfunktionalität für nicht-gehfähige BewohnerInnen in der stationären Altenpflege. In: Wollesen, B., Meixner, C., Gräf, J., Pahmeier, I., Vogt, L., & Woll, A. (Hrsg.), Interdisziplinäre Forschung und Gesundheitsförderung in Lebenswelten. Bewegung fördern, vernetzen, nachhaltig gestalten (1. Aufl., S. 86-91). Hamburg, Deutschland: *Feldhaus* (Schriften der Deutschen Vereinigung für Sportwissenschaft, 289)

Tabelle 3A

Veröffentlichte Abstracts

Abstracts
Cordes, T., Hierhager, M., Wanstrath, M., & Wollesen, B. (2018) Interventions to improve and sustain physical functioning, cognition and psychosocial well-being for elderly multimorbid nursing home residents. Paper presented at the European Conference of Sports Science, Dublin.
Cordes, T., Schoene, D., & Wollesen, B. (2019) Interventions to improve and sustain physical functioning, cognition and psychosocial wellbeing for nursing home residents who are unable to walk. Paper presented at the European Conference of Sports Science, Prague.
Cordes, T., Schoene, D., & Wollesen B. (2019) Interventionen zur Verbesserung von physischer und kognitiver Funktion und des psychosozialen Wohlbefindens für nicht gehfähige BewohnerInnen in der stationären Altenpflege. Paper presented at the 24. Sportwissenschaftlicher Hochschultag der DVS, Berlin.
Cordes, T., Schmidt, D., Jaeger, J., & Wollesen, B. (2020) Efficacy of a chair-based exercise intervention to improve the performance of activities of daily living for nursing home residents. Paper presented at the digital European Conference of Sports Science in Sevilla.
Cordes, T., Schmidt, D., Jaeger, Joscha; Wollesen, Bettina (2021) Effekte einer Trainingsintervention für Pflegeheimbewohner zur Verbesserung von Alltagsaktivitäten. Paper presented at the Sports, Medicine and Health Summit in Hamburg.
Cordes, T., Zwingmann, K., Rudisch, J., Voelcker-Rehage, C., & Wollesen, B. (2021) A multicomponent exercise intervention to improve motor functioning, cognition and psychosocial wellbeing for nursing home residents who are unable to walk. Paper presented at the EGREPA Conference in Krakow

Anhang B: Publikation 1

Cordes, T., Bischoff, L. L., Schoene, D., Schott, N., Voelcker-Rehage, C., Meixner, C., Appelles, L. M., Bebenek, M., Berwinkel, A., Hildebrand, C., Jöllenbeck, T., Johnen, B., Kemmler, W., Klotzbier, T., Korbus, H., Rudisch, J., Vogt, L., Weigelt, M., Wittelsberger, R., Zwingmann, K., … Wollesen, B. (2019). A multicomponent exercise intervention to improve physical functioning, cognition and psychosocial well-being in elderly nursing home residents: a study protocol of a randomized controlled trial in the PROCARE (prevention and occupational health in long-term care) project. *BMC Geriatrics*, *19*(1), 369. https://doi.org/10.1186/s12877-019-1386-6

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STUDY PROTOCOL

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A multicomponent exercise intervention to improve physical functioning, cognition and psychosocial well-being in elderly nursing home residents: a study protocol of a randomized controlled trial in the PROCARE (prevention and occupational health in long-term care) project

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Abstract

Background: Older adults, who are living in nursing homes that provide a high level of long-term nursing care, are characterized by multimorbidity and a high prevalence of dependency in activities of daily living. Results of recent studies indicate positive effects of structured exercise programs during long-term care for physical functioning, cognition, and psychosocial well-being. However, for frail elderly the evidence remains inconsistent. There are no evidence-based guidelines for exercises for nursing home residents that consider their individual deficits and capacities. Therefore, high-quality studies are required to examine the efficacy of exercise interventions for this multimorbid target group. The purpose of this study is to determine the feasibility and efficacy of a multicomponent exercise intervention for nursing home residents that aims to improve physical and cognitive functioning as well as quality of life.

Methods: A two-arm single-blinded multicenter randomized controlled trial will be conducted, including 48 nursing homes in eight regions of Germany with an estimated sample size of 1120 individuals. Participants will be randomly assigned to either a training or a waiting time control group. For a period of 16 weeks the training group will meet twice a week for group-based sessions (45–60 min each), which will contain exercises to improve physical functioning (strength, endurance, balance, flexibility) and cognitive-motor skills (dual-task). The intervention is organized as a progressive challenge which is successively adapted to the residents' capacities. Physical functioning, cognitive performance, and quality of life will be assessed in both study groups at baseline (pre-test), after 16-weeks (post-treatment), and after 32-weeks (retention test, intervention group only).

(Continued on next page)

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Discussion: This study will provide information about the efficacy of a multicomponent exercise program in nursing homes (performance, recruitment). Results from this trial will contribute to the evidence of multicomponent exercises, which specifically focus on cognitive-motor approaches in the maintenance of mental and physical functioning. In addition, it will help to encourage older adults to actively engage in social life. Furthermore, the findings will lead to recommendations for health promotion interventions for frail nursing home residents.

Trial registration: The trial was prospectively registered at DRKS.de with the registration number DRKS00014957 on October 9, 2018.

Keywords: Nursing home, Intervention, Physical activity, Exercise, Cognition, Frailty, Aged, ADL, Physical function, Clinical trial

Background

The worldwide population is progressively aging, which is why an increased demand for long-term care is expected [1]. Aging is associated with a decline in physical and cognitive functioning as well as with an increased occurrence of adverse health events. Consequently, the prevalence of disabilities increases substantially in the aging population, particularly after the age of 85 [2]. The condition of old people living in nursing homes is often characterized as multimorbidity at high risk of disability onset or progression [3]. This might lead to a loss of independence in activities of daily living (ADL), which is often closely associated with institutionalization and death [4]. Moreover, the declining physical functional status affects the overall quality of life of older adults [3]. Thus, effective interventions to strengthen health resources and prevent or delay disabilities and the loss of physical and cognitive functioning in older institutionalized people is a public health priority [3].

With the German Prevention Act of 2015, German nursing care insurances must provide preventive services in nursing homes that are aiming at promoting the health of residents by maintaining or improving several domains, such as physical functioning and mobility, cognition and quality of life [5]. The PROCARE project uses the BASE-program [6] to provide a strategy for the health promotion process described in the prevention guidelines [5].

The current project focusses on improving the above-mentioned goals. Therefore, a multicomponent exercise intervention program that takes the desires and preferences of the residents into account will be conducted. There is strong evidence that structured exercise programs in healthy and pre-frail older individuals can effectively improve everyday functionality, mobility, while reducing falls and physical frailty [7–12]. In addition, the positive effect of regular physical activity on cognition and on the prevention of diseases (such as cardiovascular diseases, diabetes, osteoporosis or sarcopenia) has already been demonstrated [1, 13–16]. In contrast, evidence from exercise interventions in the nursing home setting is less clear and inconsistent. A systematic review [17] showed that intervention studies in very frail and multimorbid populations cannot support the beneficial effect of exercises on functional performance and hence suggest that the degree of frailty might be critical, when reviewing the effectiveness of exercising [17]. Confirming these findings, a study with a moderate intensity group-exercise program positively influenced the reduction of falls and improved physical performance in pre-frail, but not in frail elderly nursing home residents [18]. Contrary to the findings in community-dwelling older individuals [18–20], exercise interventions have not been able to reduce falls in nursing homes [21]. Nevertheless, a few studies showed a positive impact of exercise on ADL [1, 16] and functional capacity [12, 16, 22–24] for people living in nursing homes. A systematic review investigating frail older people in nursing homes, residential care, and in the community [25] demonstrated that most studies provide evidence that exercise interventions have a positive impact on frailty. However, the definition of the term 'frailty' was different and unclear among most studies. Moreover, in the majority of studies, effect sizes were small [1] and a clear recommendation for an appropriate intervention was not given.

For cognitive outcomes and dementia, several studies with nursing home residents indicated no differences between exercise and cognitive intervention groups compared to the control group [26–31]. However, the findings also demonstrate a prominent heterogeneity regarding type, duration and frequency of exercise and severity of participants' dementia. On the other hand, some studies addressing physical training and exercises reported positive effects on cognitive performance (short-term memory recall, visuospatial abilities, multiple aspects of executive functions) in the setting of nursing homes [1, 22, 23, 32–34]. The analysis of previous studies [1, 22, 23, 26–34] indicates that programs using higher intensities (e.g., walking exercises with additional weights) and longer training periods (> 3 months; at least twice a week [35]) tend to have a greater impact on cognitive performance. Moreover, most benefits on motor and cognitive performance seem to be reached by dual-task training interventions [35].

For quality of life, exercise interventions have shown to improve older adults' well-being [23, 36], particularly depressive symptoms were reduced in people with dementia [37]. However, a large RCT, aimed at reducing depressive symptoms to increase well-being among nursing home residents, conducted a moderately intense exercise program twice a week for 12 months and found no effect [38]. A high-intensity functional exercise program aiming to reduce depressive symptoms and improve psychological well-being showed no effect among older people living in residential care facilities, but positive effects among people with dementia [36]. Nevertheless, there is neither consistent evidence, nor evidence-based physical activities, nor exercise guidelines to promote health-related outcomes (like physical and cognitive functioning and quality of life) for very old, multimorbid, and institutionalized people [39–41]. Despite the insufficient evidence, a recent report from the International Association of Gerontology and Geriatrics - Global Aging Research Network (IAGG-GARN) and the IAGG European Region Clinical Section provides first recommendations for physical activity in older persons, who are in need of care [41]. To lower the risk of developing a number of disabling medical conditions and various chronic diseases, they propose a multicomponent program administered in small groups, including training of strength, endurance, mobility, and balance, in combination with dual-task exercises in moderate intensities twice a week for 35–45 min each. The report also emphasizes continuously adapted training intensities in relation to the residents' abilities. Also, progressive enhancement, inclusion of stimulating materials and music, as well as training for movements that are often associated with falls (e.g., walking forward with changes of direction) is advised. In addition, the preferences and needs of the individuals should be discussed in advance, in order to define feasible goals and to take the residents' self-efficacy into account [42].

Overall, the effectiveness of preventive interventions in nursing homes which address these recommendations and cognitive-motor exercises is assumed, but not yet examined. Thus, more high-quality studies are needed to examine and to structure results of preventive interventions, so they can be implemented into the health care system [42].

Aims and research questions for the study

Based on the existing research and the physical activity recommendations mentioned above, a multicenter intervention study will be conducted, aiming to determine the feasibility and efficacy of a multicomponent exercise intervention program for residents of nursing homes. Moreover, we assume that these effects will improve the residents' quality of life.

Methods/design

The SPIRIT statement [43] was used as a guideline for this protocol paper.

Trial design

This study is a two-arm single-blinded randomized controlled trial of an individually tailored multicomponent intervention (see Table 1) for older men and women living in nursing homes. The study will be aptly named PROCARE – Prevention and occupational health in long-term care, as part of the PROCARE project. A stratified randomization is performed after the baseline assessment. The assessment of primary and secondary

Table 1 Description of the intervention

Program	Week 1–4	Week 5–8	Week 9–12	Week 13–16
Mobilisation and warm-up	e.g., range of motion exercises for the wrists, hip, shoulders, knees, and ankles	Cf. week 1–4	Cf. week 1–4	Cf. week 1–4
Coordination, balance, and cognitive exercises	e.g., standing balance, bodyweight shifting, motivational cognitive-motor games with group interaction including balls and scarfs	e.g., standing balance, bodyweight shifting, motivational cognitive-motor games with group interaction including balls and scarfs	e.g., standing balance with feet together, side-by-side, bodyweight shifting, motivational cognitive-motor games with group interaction including balls and scarfs	e.g., standing balance with feet together, side-by-side, semi-tandem, tandem, standing on one leg, bodyweight shifting, motivational cognitive-motor games with group interaction including balls and scarfs
Dual-task walking exercises (endurance)	150-180 m e.g., brisk walking, starting, stopping, avoiding obstacles, turns	180-240 m e.g., brisk walking, starting, stopping, avoiding obstacles, turns	240-300 m e.g., brisk walking, starting, stopping, avoiding obstacles, turns, dual-task conditions e.g., carrying a cup, repeating rows of numbers, paying attention to signs	300-330 m e.g., brisk walking, starting, stopping, avoiding obstacles, turns, dual-task conditions e.g., carrying a cup, repeating rows of numbers, paying attention to signs
Calm down	e.g., stretching and relaxing exercises	Cf. week 1–4	Cf. week 1–4	Cf. week 1–4

outcomes takes place in all subjects upon entry to the study (T1) by a blinded assessor and is repeated at 16 weeks (T2), and at 32 weeks (T3, retention test, intervention group only) after randomization (see Table 2). *The trial is registered at DRKS.de with registration number* DRKS00014957.

Participants, interventions, and outcomes

Ethics approval

The trial is conducted in agreement with the principles of the Declaration of Helsinki and the guidelines of Good Clinical Practice (GCP). All participants or their legal guardians give written informed consent prior to the study enrollment. The ethics committee of the Hamburg Chamber of Physicians, Germany, has approved the study protocol *(PV5762)*.

Recruitment of nursing homes

Eight cities and their surroundings throughout various regions in Germany (Bremen, Chemnitz, Frankfurt, Hamburg, Karlsruhe, Nuremberg, Paderborn and Stuttgart) will recruit 48 nursing homes in total (six per site). The institutions involved are deliberately selected based on their basic structural figures (number of nursing places, number of employees, urban or rural district, social-economic status), in order to analyze the applicability of the program under a wide range of conditions. Therefore, a list of all nursing homes will be created. It will then be stratified by their structural characteristics and afterwards the nursing homes will be randomly selected. Participation is voluntary and will not be remunerated. In case a requested nursing home declines to participate, another facility with similar characteristics will be requested instead.

Recruitment of participants

Assessment of eligibility and recruitment of participants with respect to inclusion and exclusion criteria will be primarily based on nursing documentation and staff consultation. Care management and lead investigators will meet to discuss and create a list with suitable nursing home residents, prior to the study enrollment. It will be made clear that the intervention is targeting everyone who meets the inclusion criteria and not only those who are very open to physical activities and therefore might be more likely to show a positive response to the intervention. Even the very institutionalized, frail residents will be encouraged to participate. Nevertheless, it is a voluntary intervention and there is still room for bias because the individual reasons for participation will remain unclear. After the selection process, nursing staff will inform all suitable residents or their legal guardians about the study goals and ask for voluntary participation. All verbally consented participants or their legal guardians will give written informed consent prior to the study enrollment.

Eligibility criteria

Inclusion criteria are *i)* willingness to participate, *ii)* ability to participate in group activities, *iii)* ability to sit unassisted on a chair or in a wheelchair, and *iv)* the ability to understand and execute simple instructions. No other inclusion or exclusion criteria will be applied.

Assignment of interventions

Assessment and data collection will be done by blinded assessors in a strictly pseudonymized form to guarantee a blinded data analysis.

To avoid performance bias, the measurements and the intervention follow a standardized protocol. All participant information and data will be stored securely and identified by a coded ID number only to maintain the participants' confidentiality.

To avoid selection bias, a stratified randomization will be conducted to divide the participants into either an intervention group or a waiting time control group. The random allocation will be stratified and executed by lot by the director of the study who will receive the pseudonymized codes of the participants and their baseline characteristics and will not be involved in neither the assessment nor the intervention procedures. Stratification will be based on comparable sex, age, and cognitive performance (according to the Montreal Cognitive Assessment MoCA-Score [44]) to avoid differences in the baseline characteristics of the groups. After assigning the participants to either the intervention or waiting time control group, the pseudonymized participant codes will be sent to the study investigators who are responsible for the data management. The exercise scientist or physiotherapist, who will conduct the intervention, will receive only names of the participants in the intervention group and after 16 weeks names of the waiting time control group without being aware of the control group design.

Outcome measures

The assessment will focus on three key domains: physical functioning, cognitive performance, and psychosocial well-being. Apart from the following primary and secondary outcomes, demographic and baseline characteristics, like age, height, weight, Body Mass Index, and sex, will be measured.

Primary outcomes

The following primary outcomes will be measured to evaluate the efficacy of the intervention program:

Table 2 Schedule of enrolment, interventions, and assessments

	Study Period				
	Enrolment	**Baseline Assessment**	**Allocation**	**Post-Allocation**	**Close-out**
					at 32 weeks
ENROLMENT:					
Eligibility screen	X				
Informed consent	X				
Allocation			X		
INTERVENTIONS:					
Intervention group			←—	—→	
Waiting time control group				←—	—→
ASSESSMENTS:					
Baseline variables: Age, height, weight, BMI, sex	X				
Barthel Index		X		X	X
MoCA		X		X	X
SF12		X		X	X
Gait analysis		X		X	X
SST		X		X	X
VFT		X		X	X
SPPB		X		X	X
SWLS		X		X	X
Hand Grip Strengh		X		X	X
Frailty		X		X	X
CES-D		X		X	X
FES-I		X		X	X
Functional reach		X		X	X
Falls				X	X
Drop outs				X	X

Physical functioning The *Short Physical Performance Battery* (SPPB) [45] is a standardized instrument to test the lower extremity functionality (balance, gait speed, leg strength). Participants are required to show a stable stand in an upright position under three conditions (legs closed/feet together, semi-tandem stand, tandem stand). After that, comfortable gait speed will be assessed by measuring the time to walk a 4-m track, starting from a standing position and stopping when the first foot is past the 4-m line. Finally, a five times sit-to-stand transfer will be completed as fast as possible. Each domain is scored between 0 and 4 and SPPB overall scores range from 0 (low mobility/functionality) to 12 (full mobility/functionality). Clinically relevant improvements have been demonstrated to range between 0.99 and 1.34 points for the SPPB [45].

Gait analysis (GAITRite: CIR Systems Inc., Clifton, NJ, USA, Optogait: Microgate, Bolzano, Italy, Mobility-Lab: APDM Inc., Portland, USA, GaitUp: SA, Lausanne, Switzerland or Zebris PDM, Isny, Germany). Gait performance will be assessed by measuring step length, step width, gait speed, and double support phase on a 10-m track, using of one of the mentioned gait analysis systems. Each participant completes three trials: a test trial, one trial at preferred walking speed, and one trial at maximum walking speed. Measured data will be recorded and saved for later analysis by the gait systems software. An accompanying validation study will secure the comparability of the different gait measurement systems.

Dual-task cognitive performance The *Serial Sevens Test* (SST) [46] aims to assess cognitive functioning. During the SST, participants are being asked to count down from a certain number in steps of seven. Due to the poor cognitive functioning of most participants, a simpler version of the SST will be administered, in which participants have to count down in steps of 3 (S3T) and steps of 1 (S1T). The S3T and S1T will be tested during a single- and dual-task condition (i.e. during gait), in order to evaluate the cost of dual-tasking for cognitive functioning. The number of correct answers within 15 s will be recorded during single- and dual-task conditions as well as the gait parameters step length, step width, gait speed, and double support phase under dual-task conditions with a gait analysis system.

The *Verbal Fluency Test* (VFT) is an additional test for cognitive functioning and part of the MoCA [44]. The VFT is a phonemic fluency test, in which participants are asked to name as many words as possible in a certain time, starting with a specific letter (not allowed are names or numbers). It was shown that verbal fluency is reduced in elderly people with mild cognitive impairments as compared to their non-impaired peers [47]. In accordance to the S3T and S1T, the VFT will be administered during single- and dual-task conditions, to evaluate the cost of dual-tasking for cognitive functioning. The number of correct answers within 15 s will be recorded during single- and dual-task conditions as well as the gait parameters step length, step width, gait speed, and double support phase under dual-task conditions with a gait analysis system.

Psychosocial well-being The short form of the *Health Survey SF12* [48] is a questionnaire, which can be used to examine the health-related quality of life of the participants, who rate their quality of life via twelve items. The items regard eight health concepts which are commonly represented in widely used surveys: (1) physical functioning, (2) role limitations due to physical health problems, (3) bodily pain, (4) general health, (5) vitality (energy/fatigue), (6) social functioning, (7) role limitations due to emotional problems, and (8) mental health (psychological distress and psychological well-being) [49]. The SF12 physical and mental component summary scales are scored using norm-based methods. Both scales are transformed to have a mean of 50 and a standard deviation of 10 in the general U.S. population. All scores above and below 50 are above and below the average [49].

The *Satisfaction with Life Scale* SWLS [49] is a brief instrument with five items to measure global cognitive judgements of satisfaction with one's life on a seven-point Likert scale. High scores indicate a high satisfaction with life, while low scores indicate a low degree of satisfaction.

Secondary outcomes

The following secondary outcomes will be measured to evaluate the efficacy of the intervention program:

Physical functioning The *Barthel Index* [50] is used to systematically record the independence of participants when performing basic ADL via ten items. Feeding, personal toileting, bathing, dressing and undressing, getting on and off a toilet, controlling bladder, controlling bowel, moving from wheelchair to bed and returning, walking on level surface (or propelling a wheelchair if unable to walk) and ascending and descending stairs are rated on a scale from 0 to 15 points depending on the item. Total possible scores range from 0 (totally dependent) to 100 (fully independent) [50].

Hand Grip Strength is measured with a hydraulic hand dynamometer (JAMAR, hydraulic hand dynamometer). Three trials with each hand will be executed. Results will also be used to assess the frailty index item weakness.

The *Functional reach* [51] is a clinical measure of balance. It assesses the difference between the arm's length and maximal forward reach in cm, using a fixed base of support. The test will be executed in a sitting position. The participant sits against the back of a chair next to a wall reaching forward as far as possible without losing balance. Reach distance will be measured with a scale attached to the wall.

For the measurement of *Frailty* this study will apply the original operationalization of the Frailty Phenotype from the Cardiovascular Health Study [52] to enable comparability. A frailty index will be formed out of five measured factors, including an unintentional weight loss of more than 4.5 kg in the past 12 months (shrinking), BMI- and sex-adjusted hand grip strength (weakness), frequency of fatigue in the last week by using two items of the Center of Epidemiological Studies-Depression Scale (CES-D, exhaustion), height- and sex-adjusted gait speed (slowness) and sex-adjusted energy expenditure by physical activity (modified Minnesota Leisure Time Physical Activity Questionnaire).

The short form of the *Falls Efficacy Scale-International* (Short-FES-I) [53] is a seven-item questionnaire with a scoring range between one and four, which provides information on the level of concern about falls for a range of activities of daily living. The number of falls, fall-related injuries and deaths occurring during the 32-week period will be documented by nursing staff.

Cognitive performance The *Montreal Cognitive Assessment* (MoCA) [44] is a brief screening tool of global cognition to reveal mild cognitive impairment and an early stage of Alzheimer's disease. It assesses several cognitive domains, like short-term memory recall, visuospatial abilities, multiple aspects of executive functions, attention, concentration and working memory, language and orientation to time and place. MoCA scores range between 0 and 30. A score of 26 or above is considered to be normal [44].

Psychosocial well-being The *Center for Epidemiological Studies Depression Scale* (CES-D) [54] is used to screen for depressive symptoms and mood disorders with an eleven-items questionnaire, scoring between zero and three points for each item. It has demonstrated validity for research conducted in elderly populations [55]. Two items regarding the exhaustion of residents ("Everything was effort"; "I could not get going") will also be used to assess the 'exhaustion' for the frailty index.

Intervention

The exercise program consists of 32 sessions for a period of 16 weeks. One training session has a duration of 45–60 min and takes place twice a week. Exercise sessions will be administered by at least one certified exercise scientist or physiotherapist with group sizes ranging from four to 15 participants. The program follows IAGG guidelines and combines previously published exercises that have proven to be beneficial for cognitive-motor performance in older people in the community and in need of care [7, 8, 12, 20, 35, 56–59]. Training focusses on daily situations which are commonly associated with an increased fall risk and it mostly includes challenging walking exercises (e.g., brisk walking, starting, stopping, avoiding obstacles, turns). During these exercises, participants are also exposed to a variety of cognitive tasks under single- and dual-task conditions, designed to challenge their focus of attention with acoustic and visual stimuli and specific executive functions. Furthermore, exercises for strength, balance and flexibility as well as endurance performance associated with walking are integrated.

To ensure a controllable structure, training sessions are divided in five parts: 1. 5–10 min mobilisation and warm-up (e.g., range of motion exercises for the wrists, hip, shoulders, knees, and ankles). 2. 10 min coordination, balance, and cognitive exercises (e.g., standing balance, bodyweight shifting, motivational cognitive-motor games with group interaction including balls and scarfs). 3. 20 min aerobic walking exercises (e.g., under different single and dual-task conditions). 4. 10 min strength exercises (e.g., chair rises, upper body and trunk exercises with additional materials and weights, functional lower-limb exercises). 5. 5–10 min calm down (e.g., stretching and relaxing exercises).

During the first step of the conceptualization, qualitative guided interviews were conducted with five residents of a nursing home facility. The interviews assessed different domains regarding ADL, need of support, participation in social activities as well as expectations and wishes regarding a training program. Moreover, a feasibility study (currently under review) was conducted to examine the adherence and acceptance of the program. Taking into account these previously inquired desires and preferences of the residents, a focus is set on everyday skills to promote ADL, cognition and psychosocial resources. For example, by using motivational equipment with different colors and music during the exercise sessions, a stimulating environment will be provided to promote participant's retention. The exercise program will be continuously adapted to the residents' capacity and hence, it is organized as a progressive challenge to expand participants' resources in accordance to the F.I.I.T. principle [60]. The intensity of exercises will vary between moderate and vigorous. This will be ensured by adjusting the duration, frequency, difficulty, range of motion and/or intensity of the exercises. For example, endurance exercises, like 15 m walks, will range from ten up to 22 walks within one session. For residents who are unable to walk a program will be conducted with exercises exclusively in a sitting position. Regarding resistance exercises, progression will be ensured by adjusting the number of repetitions (from 5 to 10 to 15 to 20), the number of sets (1, 2 or 3), and/or by usage of additional weights (1 or 2 kg). For executing static, dynamic balance, and coordination exercises the difficulty level will be raised by changing exercise positions (e.g., sitting, standing, feet together, side-by-side, semi-tandem, tandem, standing on one leg). To assess the intensity of training, instructors will use the Borg Scale of Perceived Exertion [61].

Discontinuation of the intervention may occur in case of health decline or if a participant wishes to stop taking part in the group intervention. To improve adherence and to promote retention, the therapists will give explanations about the purpose of the intervention and the possible benefits of the exercises. Attendance of each participant will be recorded and reasons for drop outs will be documented. No other concomitant group exercise interventions are permitted besides usual care and physiotherapy. Control group participants will be asked to continue their regular everyday activities.

Data collection, management, and analysis

Statistical analysis

We will evaluate the effects of the intervention on every quantitative, qualitative, and ordinal outcome, using repeated measures or mixed models, "t" tests, Kruskall-Wallis Mann-Witney tests or the Chi-square tests, depending on the type of outcome and their normal or non-normal distribution. The primary analysis will be a mixed model between-group comparison of the SPPB, gait variables, Serial Sevens, and Verbal Fluency Test, utilising all available data points during follow-up. We will use the Bonferroni correction to appropriately adjust the overall level of significance for multiple comparisons. Between-group differences for all primary and secondary outcomes will be adjusted for baseline values, age, sex, and education. Secondary outcomes will be analysed with similar methodology, using repeated measures mixed model between-group comparisons. All statistical analyses will be performed using SPSS Statistics for Windows (version 25.0, IBM). Statistical significance level is set at $p < 0.05$.

Intention-to-treat analysis will be performed (participants who are randomized into groups after the collection of baseline data). For the intention-to-treat analysis, data of all trial patients in the groups to which they were randomized will be processed, regardless of whether they received or adhered to the allocated intervention. It is assumed that the majority of participants in the two arms will receive the appropriate number of intervention sessions. In addition, a per-protocol analysis of the participants who completed the study without major protocol violation (e.g., who attended more than 80% of the training sessions), will be performed. The per-protocol analysis will be performed as a secondary analysis, if there is a sufficient number of participants in the two arms, who do not receive the intervention protocol or are lost to outcome assessment. Data from those participants, who do not violate the treatment protocols, will be included in the per-protocol analysis. The multiple imputation (MI) technique will be used for dealing with missing data under the assumption that data are missing at random.

Sample size estimate / power calculations

The required sample size was calculated with G*Power (Version 3.1.9.2, Heinrich Heine University of Duesseldorf) [62]. The sample size calculation was approximated with a 2 × 3-factorial analysis of variance (ANOVA) for repeated measures (within-between interaction, small effect size, power of .80 [1-β], 2-sided α-error (95% CI), 2 groups, 3 measurements) based on the primary outcome Short Physical Performance Battery (SPPB). The small effect size used for the calculation of required sample size is based on literature reviews and assumptions of clinically relevant changes for residents in nursing homes with probable cognitive impairment [63]. One hundred eight individuals per region are required in order to detect a clinically meaningful change of ≥1.0 point with a SD of 0.99 points. To account for potential dropouts before study completion, we will inflate the sample size by 30% (20% losses during follow-up; 10% mortality), resulting in a total sample size of 1120 individuals (140 per centre with 70 participants allocated to each group).

Monitoring

A data monitoring committee, responsible for data monitoring, interim analyses and auditing, will not be established, because no adverse events are to be expected. However, study participants will be under the surveillance of trained project staff, who will intervene, if a negative reaction is observed during the measurements and training interventions. Nevertheless, grant holders are part of a PROCARE advisory board and responsible for data audits every 5 months.

Dissemination

The results of the study will be published in open-access and international journals. In addition, the results will be presented at conferences as well as in the participating nursing homes.

Discussion

To determine the efficacy and feasibility of a multicomponent exercise intervention for nursing home residents, a multicenter intervention study will be conducted. We assume improvements or a slower decline of frail and pre-frail residents' physical and cognitive functioning as well as psychosocial well-being compared to a waiting time control group.

Preventive physical activity interventions could preserve the health-related quality of life of nursing home residents, since a reduction is based particularly on a loss of physical functioning [41]. We propose, that nursing home residents with severe physical and cognitive impairment might benefit from participation in physical activity interventions, because of their low functional status at the beginning and a higher physiological adaptation to a progressive training intensity [41].

There are only vague guidelines for the content, intensity, frequency, and duration of physical activity in the nursing home setting [40], yet. High-quality studies are required to close this gap and provide effective and efficient exercise modalities for this setting. The results of the present study will yield recommendations for exercise interventions, which then can be implemented into the health care system.

The intervention of this study program combines components of exercise programs that have proven to gain health benefits for residents in nursing homes [1, 12, 16] in residential care [7, 56], and in older adults living in the community [20, 35, 57–59], with a special focus on cognitive-motor exercises. Furthermore, based on this multicomponent program with strength, balance, and dual-task components, the findings will help to derive valid recommendations for activities and guidelines for health promotion in nursing home residents. Results from this trial will particularly contribute to the evidence on cognitive-motor approaches in the maintenance of mental and physical functioning. It will also offer potential ways to encourage nursing home residents to participate actively in social life within the care setting, by providing a program that is appropriate and adapted to residents' capacities, needs and desires. To this end, the findings may provide suggestions and support to deal with present and future challenges, occurring at health promotion initiatives in the setting of nursing homes, a sector that likely will gain more relevance in times of the demographic change. With the Prevention Act of 2015, German health insurances have to provide preventive services in nursing homes [5]. The trial will show that universal prevention through physical activity interventions in this setting in late life care is possible and useful to improve health status and personal resources of nursing home residents.

Abbreviations

ADL: Activities of daily living; BMI: Body Mass Index; CES-D: Center for Epidemiological Studies Depression Scale; FES-I: Falls Efficacy Scale international; GCP: Good Clinical Practice; GDS: Geriatric Depression Scale; MoCa: Montreal Cognitive Assessment; PROCARE: Prevention and occupational health in long term care; S1T: Serial 1 Test; S3T: Serial 3 Test; SD: Standard deviation; SF 12: Short Form (12 questionnaire) SF 36 Health Survey; SPPB: Short Physical Performance Battery; SST: Serial Sevens Test; SWLS: Satisfaction with Life Scale; TWT: Trail Walking Test; VFT: Verbal Fluency Test

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Authors' contributions

This study protocol was carried out in collaboration between all authors. BW had the project idea and is the head of the multicenter study. Study contents were additionally refined by CVR, TJ, MW, NS, DS and LV who are grant holders and lead investigators. All authors were involved in the design of the study protocol. TC, DS, JR and BW developed the intervention with revision of all authors. TC wrote the first draft of the manuscript. NS calculated the sample size according to data analysis plan and wrote the statistical section. TC, LB, DS, NS, CVR, LA, MB, AB, CH, TJ, BJ, WK, TK, HK, JR, LV, MW, RW, KZ, CM and BW have been involved in the drafting and contributed significantly to the revision of this manuscript and have given approval of the final manuscript.

Authors' information

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Availability of data and materials

Data can be obtained from the corresponding author upon reasonable request.

Ethics approval and consent to participate

The study was approved by the ethics committee of the Hamburg Chamber of Physicians (registration number *PV5762*). Modifications are not expected. The study protocol follows a feasibility study. All participants and their legal guardians will be informed about the study goals. Written informed consent will be obtained from all participants or their legal guardians prior to the study enrollment according to the Declaration of Helsinki. Participants as well as their relatives or legal guardians can withdraw consent at any time. All participant information and data will be stored securely and identified by a coded ID number only to maintain participants' confidentiality.

Consent for publication

Personal information about the study participants will not be published.

Competing interests

BW is an Associate Editor for BMC Geriatrics since 2019. There are no other financial or non-financial competing interests. The authors declare that they have no conflict of interest.

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Anhang C: Publikation II

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Review Article

Chair-Based Exercise Interventions for Nursing Home Residents: A Systematic Review

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chair-based
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physical function

ABSTRACT

Objectives: Despite mobility impairments, many residents have physical, cognitive, and psychosocial resources that should be promoted. The aim was to summarize the current evidence on chair-based exercise (CBE) interventions for nursing home residents.
Design: Systematic review registered with Prospero (registration number: CRD42018078196).
Setting and Participants: Nursing home residents in long-term care.
Methods: Five electronic databases were searched (MEDLINE, Embase, CINAHL, Cochrane Central, and PsycINFO) from inception until July 2020. Title, abstract, and full-text screening as well as quality assessment with the Downs and Black checklist was done by 2 independent reviewers. Studies were eligible if they (1) were conducted in nursing home residents, (2) included participants with a mean age of 65 years, (3) had at least 1 treatment arm with seated exercises only, (4) included active or inactive controls, (5) measured outcomes related to physical and/or cognitive functioning and/or well-being, and (6) controlled studies or single-group pre-post design. Because of a heterogeneity in characteristics of included studies, we refrained from conducting a meta-analysis.
Results: Ten studies met the inclusion criteria ($n = 511$, mean age 79 ± 7 years, 65% female). Studies differed in sample size (12-114) as well as in training type (multicomponent, Yoga/Qigong/breathing exercise, range of motion) and dose (frequency 2 sessions/week to daily, intensity low to moderate, time 20-60 minutes/session, 6 weeks to 6 months). Overall, CBE appears to be feasible and safe. Studies found task-specific improvements in physical and cognitive functions and enhanced well-being. Three studies demonstrated improved lower body performance following a multicomponent CBE program in mobile residents. Three studies only including residents unable to walk reported improved physical functions, indicating that immobile residents benefit from CBE programs. There was a lack of separating mobile and immobile residents in analyses.
Conclusions and Implications: The results indicate that CBE interventions may improve physical and cognitive functions as well as well-being in nursing home residents. Task-specific multicomponent CBE appears to be best for improving different domains of physical and cognitive functioning. More high-quality trials are needed.

Nursing home residents deal with limitations in basic activities of daily living (ADL)[1] and 70% have mobility restrictions including the inability to walk or transfer from bed or chair.[2] These ADL are fundamental for maintaining independence. About 50% of people who are living in nursing homes are considered frail and 40% prefrail.[3] Reduced physical functioning in relation to ADL is associated with a reduced health-related quality of life (HR-QoL),[4,5] especially in nursing home residents with dementia.[6,7] Nonetheless, nursing home residents have resources relating to the trainability of physical functioning,[8] cognition,[9] and improvements in psychosocial well-being.[2,5] The goal of prevention in geriatric care is to ensure the highest degree of self-determination with the best possible HR-QoL.[2,10] Effective interventions that strengthen these resources by improving or maintaining current levels are therefore required.

The authors declare no conflicts of interest.

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There is broad consensus that exercise is a type of intervention that can improve physical and cognitive performance and psychosocial well-being[11] even in very frail and the oldest-old.[12–15] In nursing home residents, physical performance decreases over time without appropriate exercise programs, which worsens the ability to perform ADL and reduces HR-QoL.[16,17] However, most scientific interventions are conceptualized for residents who are still able to walk.[8,18,19] Because of physical limitations such as muscle weakness and impaired balance,[20] many residents in nursing homes use wheelchairs as their primary means of mobility.[21,22] Thus, participants who are unable to walk are excluded from these trials. Yet it is our experience that most of the administered group trainings in practice are chair-based. Hence, there is a conceptual gap in the field of prevention in nursing home care that needs to be closed.[8]

Chair-based exercise (CBE), performed in a seated position, is used as an alternative and may be an acceptable and accessible form of exercise for older people with physical limitations who may not be able to take part in other exercise programs.[23,24] To our knowledge, no systematic review concerned with the effects of CBE in nursing home residents has been published. In community-dwelling frail older people, CBE was found to be beneficial for maintaining or promoting independence and mobility.[25] However, the quality of included studies was poor[24] therefore, there is little guidance for clinical practice. Precise information for training modalities, for example, duration, frequency, and how to adjust a suitable intensity to provide a sufficient stimulus for muscle adaptation is missing. Dose-response relationships have yet to be clarified.[26] The aim of this systematic review is to summarize the current evidence on CBE interventions for nursing home residents. The results of this review are important for developing appropriate CBE interventions for nursing home residents.

Objectives

We attempted to answer the following questions:

- Do CBE interventions improve or sustain physical functioning, cognition and psychosocial well-being?
- Which types of CBE interventions are used and most effective?
- Are there any dose-response relationships and how should CBE interventions be methodically adjusted?

Methods

The systematic review was registered with Prospero (registration number: CRD42018078196) and applied to the PRISMA statement.[27]

Search Strategy and Eligibility Criteria

Five electronic databases (Embase, MEDLINE, CINAHL, Cochrane Central, PsycINFO) were searched from their inception until July 29, 2020. MeSH terms and relevant keywords were used to identify studies. The search strategy used in MEDLINE is presented in Supplementary Table 1.

Studies were considered to be eligible for inclusion using the following criteria based on the PICO model[28]:

1. Population: participants aged >60 years or mean age 65 years living in nursing homes or other institutionalized long-term living facilities of geriatric care;
2. Intervention: 1 treatment arm with CBE only or same interventions in all groups with added CBE in intervention group only;
3. Comparison: active or inactive control conditions, including usual care, sham interventions, leisure activities, or other exercise interventions;
4. Outcomes: related to physical, cognitive functioning or psychosocial well-being

Studies were excluded if they (1) investigated disease-specific populations (other than multimorbidity, frailty, and dementia because of their high prevalence in nursing care), and (2) contained standing or walking exercises. Studies in languages other than English or German and abstracts, theses, or protocol papers were also excluded from analysis.

Study Selection and Extraction Process

Two independent reviewers (T.C., D.S.) scanned titles, abstracts, and relevant full-text articles to identify eligible studies. Any disagreement was resolved by discussion or arbitration by a third reviewer. Reference lists of relevant studies and systematic reviews were cross-referenced by hand searching to identify additional articles missed by the database searches.

Data extraction was performed by 2 independent reviewers (T.C., D.S.) using a specifically developed and piloted (2 studies) form. In case of disagreement, a third reviewer was consulted. Information on study design, aims, sample size and characteristics, intervention and control group content and dose, outcome measures, and results were extracted.

Assessment of Methodological Quality

The quality assessment was done independently by 2 reviewers (T.C., D.S.) using the 27-item Downs and Black checklist.[29] The criteria were (1) reporting, (2) external validity, (3) bias, (4) confounding, and (5) power. We modified the power item by scoring positive if an a priori power calculation was performed. Answers were scored 0 or 1 (item 5 in reporting subscale 0 to 2). Downs and Black quality levels are excellent (26-28), good (20-25), fair (15-19), and poor ($\leq$14).[29]

Assessment of the Intervention

The exercise programs were analyzed with regard to the content of the intervention, their efficacy, specific characteristics of the training methodology, and the components referred to as FITT (frequency, intensity, time, and type) principle.[30] This included principles of dose adjustment and progression. A definition of the principles and exercise recommendations for ambulatory older adults in nursing homes who are dependent in basic ADL, retrieved from the International Association of Gerontology and Geriatrics–Global Aging Research Network (IAGG-GARN) taskforce[31] are displayed in Table 1. The exercise programs of included studies were analyzed and interpreted based on these principles.

Data Analysis

Because of the heterogeneity in intervention characteristics and outcome measures used, we refrained from conducting meta-analysis. Instead, information was narratively synthesized.

Results

Database searches and reference lists identified 1064 articles, of which 10 were deemed eligible and used for analysis (Supplementary Table 2). Figure 1 displays the flow of the study selection process.

Table 2 provides an overview of all included studies and their characteristics. The main results of the studies and descriptions of the interventions can be found in Table 3.

Table 1
FITT Principles and Recommendations for Exercises for Older Adults in Nursing Homes Who Are Ambulatory and Dependent in Basic ADL From a Taskforce Report[31]

	Definition	Recommendations
Frequency	Number of times per week	Twice a week, with an interval of at least 48 h between sessions. Higher weekly frequency is safe and may be feasible for fitter residents.
Intensity	How hard the workout should be	Moderate-intensity exercises are feasible, effective, and safe. Moderate training can be achieved by performing (1) strength, 1 or 2 sets of exercises, performed at 13-15 repetitions maximum; (2) aerobic exercises that noticeably increase heart and respiratory frequency, without generating breathlessness or undue fatigue (scoring 5 or 6 in a 10-point scale of perceived effort). High-intensity exercises can be executed, but it may require a closer monitoring.
Time	How many minutes or repetitions of an exercise are needed at a specified intensity during 1 session	35-45 minutes per session. Lesser durations may be needed during the first weeks of exercise. Longer sessions are feasible for most people.
Type	What kind of exercise (aerobic, muscle-strengthening, balance, flexibility) should be performed	The best exercise type is a multicomponent training composed of muscle strength and cardiorespiratory endurance exercises as the core components. Other exercise types, particularly flexibility and balance, should be added to the exercise program whenever possible.

Characteristics of the Participants

The sample size in the included studies ranged from 12 to 114 participants. Using weighted means, participants' age was 79 (76-92) years and 65% were female. Three studies included wheelchair users only.[34,35,39] 3 studies integrated both ambulatory residents and participants who were unable to walk,[33,36,38] and 3 studies included ambulatory residents only.[32,40,41] For 1 study, the mobility status could not be determined.[37,40] One study[40] included only residents with cognitive impairments. In all other studies, participants were described as multimorbid, frail, and/or at early stages of dementia.[32–39,41]

Analysis of the Types of Exercise Programs and Their Efficacy

Multicomponent exercise programs

Six studies[32,34,37–41] yielded positive results. They combined strength and/or aerobic training with flexibility, mobility, and coordination exercises. Five studies[32,34,37,39,41] found significant improvements in physical function. Three studies[32,38,40] including 1

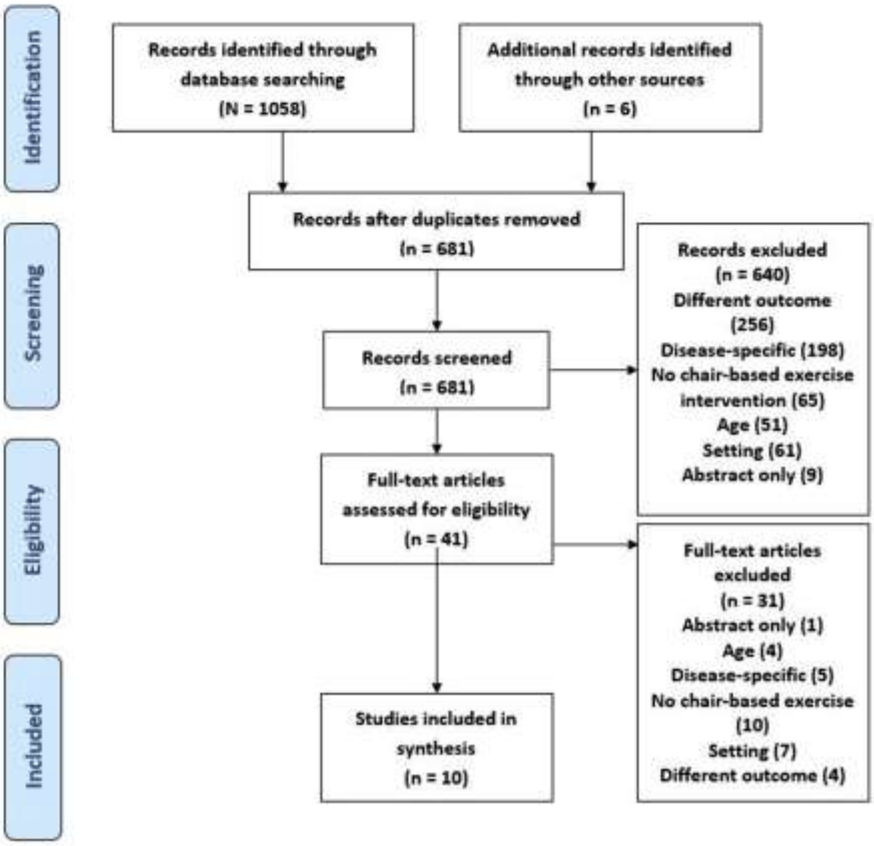

Fig. 1. Process of selection of studies for systematic review based on PRISMA flow diagram.

Table 2
Characteristics of Included Studies

Author, Year	Study Design	Study Aims	Sample Size	Sample Characteristics	Outcomes Measures
Baum et al, 2003[32]	RCT Single-blind	Determine whether a strength and flexibility program improved function	20	Age 75-99 y, nursing home residents, able to ambulate alone or with assistance	Physical function: TUG, BBS, PPT Cognitive function: MMSE Psychosocial: NA Baseline, 3, 6, 9, and 12 mo
Cebrià et al, 2014[33]	RCT Single-blind	Evaluate the effects of ITT and YRT on RM function	81	Mean age 85 y, nursing home residents, 38% wheelchair, 62% unable to walk >10 m	Physical function: RM function Cognitive function: NA Psychosocial: NA Baseline, 3, 6, and 9 wk
Chen et al, 2015[34]	Cluster randomized trial No blinding	Test the effectiveness of 6-month wheelchair-bound senior elastic band exercises on the functional fitness	114	Mean age 79 (±7) y, 49% female, nursing home residents, using wheelchairs for mobility	Physical function: ADL, lung capacity, upper body and lower body flexibility, hand grip strength, upper and lower limb muscle endurance Cognitive function: NA Psychosocial: NA Baseline, 3 and 6 mo
Kuan et al, 2012[35]	Pre-post, nonequivalent control No blinding	Test the effects of a 12-wk Qigong exercise program on the physiological and psychological health	72	Mean age 76 (±12) y, male (53%), nursing home residents, wheelchair-bound	Physical function: BP, HRV, DST Cognitive function: NA Psychosocial: BSRS-5 Baseline, 4, 8, and 12 wk
Lazowski et al, 1999[36]	RCT Double-blind	Evaluation of the FFLTC program in comparison with a seated, group-based program limited to range of motion exercises	68	Mean age 80 (±1) y, nursing home residents, 50% used a walking aid, 40% used a wheelchair	Physical function: TUG, BBS, gait speed, stair climbing power, FIM, upper and lower extremities function, FR Cognitive function: NA Psychosocial: NA Baseline, 4 mo
Nagai et al, 2011[37]	Nonrandomized crossover Single-blind	Investigate the effects of toe and ankle training	54	Mean age 83 (±7) y, 87% female, nursing home residents, mobility status NR	Physical function: Quadriceps strength, toe flexor force, balance, agility, TUG, FR, FES Cognitive function: NA Psychosocial: HR-QoL Baseline, 8 wk
Payten et al, 1994[38]	Pre-post No blinding	Investigate the need for a separate exercise program and whether residents who are not participating in the large group would benefit from a smaller group exercise program	12	Age 82-101 y, 90% female, nursing home residents, 8 ambulatory, 4 in wheelchair	Physical function: NA Cognitive function: NA Psychosocial: HR-QoL, socialization, participation, attention span, sleep pattern, mood swings, depression, wandering, aggression Baseline, 8 and 16 wk
Pomeroy, 1993[39]	Randomized crossover No blinding	Investigate whether the provision of physiotherapy input improves or maintains mobility skills	24	Age 65-91 y, 66% female, nursing home residents, not able to stand or walk	Physical function: ADL mobility assessment Cognitive function: NA Psychosocial: NA Baseline, 6 and 12 wk
Thurm et al, 2011[40]	Nonrandomized controlled trial No blinding	Investigate whether a 10-wk multimodal movement intervention conducted in the seated position can slow cognitive deterioration	19	Age 74-92 y, 70% female, frail and demented nursing home residents, relied on walking aids	Physical function: ADL, IADL Cognitive function: MMSE, ADAS-Cog, verbal fluency, phonematic fluency Psychosocial: GDS-15 Baseline, 24 wk
Rieping et al, 2019[41]	Controlled trial No blinding Randomization NR	Investigate the effectiveness of 2 CBE programs on biologic stress, physical fitness, and functional autonomy	47	Age 80 (±8) y, 100% female, ambulatory nursing home residents	Physical function: Back scratch, chair stand, arm curl, TUG, FES, ADL, IADL Cognitive function: NA Psychosocial: NA Baseline, 14 wk

ADAS-Cog, Alzheimer Disease Assessment Scale–Cognitive Subscale; BBS, Berg Balance Scale; BP, systolic and diastolic blood pressure; BSRS-5, Brief Symptom Rating Scale–5; DST, distal skin temperature; FES, Falls Efficacy Scale; FFLTC, Functional Fitness For Long-Term Care; FIM, Functional Independence Measure; FR, functional reach; GDS-15, Geriatric Depression Scale–15; HRV, heart rate variability; (I)ADL, (instrumental) activities of daily living; ITT, inspiratory threshold training; MMSE, Mini-Mental State Exam; NA, not assessed; NR, not reported; PPT, Physical Performance Test; RM, respiratory muscle; TUG, timed up and go test; YRT, yoga respiratory training.

cognitive-motor training,[40] which combined motor exercises with mental and memory exercises, found improvements in cognitive functions. Another study[38] administering aerobic exercises and slow and rhythmic movements with various equipment and music found positive effects in cognition and well-being.

Yoga and breathing exercise programs

Both studies with Yoga, Qigong, and breathing exercises[33,35] reported improvements in respiratory muscle function or blood pressure.

Range of motion (ROM) exercise program

One study[36] focused on upper body ROM exercises and found improved shoulder strength but significant deterioration in hip strength, mobility, and functional ability after 12 weeks of training.

Equipment

Five studies[32,36–39] used motivational equipment to create an engaging and joyful environment and to encourage training adherence and well-being. Improvements in residents' well-being were found in the 2 studies that measured it.[37,38]

Table 3
Intervention Characteristics and Results

Author, Year	Intervention Characteristics	Intervention Content and Equipment	Results
Baum et al, 2003[32]	Type: Multicomponent strength and flexibility program Frequency: 3 times/wk Time: 60 min each session, for 6 mo Intensity: moderate, progression as tolerated (one set of 5 reps progressed to 2 sets of 10 reps)	Resistance training with ankle and wrist weights: 2-4 lb, Thera Bands: 2.5-9 lb, weighted hand-sized balls	Physical function ↑ TUG 24 s ($P < .013$), BBS score 5.3 points ($P < .013$), PPT 2.7 points ($P < .013$) Cognitive function ↑ MMSE score 4.2 points ($P < .013$) Psychosocial well-being NA
Cebrià et al, 2014[33]	Type: Yoga and breathing exercise, I1: ITT, I2: YRT Frequency: 5 times/wk Time: 20 min each session for 6 wk Intensity: low-moderate, increasing complexity, repetitions, and resistance as tolerated	Interval-based yoga and breathing exercise consisting of 7 cycles of 2 min work and 1 min rest	Physical function ↑ RM function F 6.755 ($P < .001$) Cognitive function NA Psychosocial well-being NA
Chen et al, 2015[34]	Type: Multicomponent elastic band exercise program Frequency: 3 times/wk Time: 40 min, 6 mo Intensity: moderate, 1-3-mo basic, 4-6-mo advanced (more exercises)	Warmup, aerobic motion, and harmonic stretching with elastic band exercises	Physical function ↑ ADL F 4.74 ($P < .032$), lung capacity F 23.48 ($P < .001$), hand grip strength F 9.92 ($P < .002$), upper limbs muscle endurance F 37.76 ($P < .001$), lower limbs muscle endurance F 8.27 ($P < .005$) Cognitive function NA Psychosocial well-being NA
Kuan et al, 2012[35]	Type: Yoga and breathing exercise, Ho-gong (type of Qigong) Frequency: 5 times/wk Time: 35 min, 12 wk Intensity: low	Energy-building exercises as well as methods of adjusting the spine, soft self-massage, breathing control and relaxing	Physical function ↑ BP 30 mm Hg, F 86.75 ($P < .001$), DST 4.1°C, F 78.06 ($P < .001$) Cognitive function NA Psychosocial well-being ↑ BSRS-5 score 5.9 points, F 103.63 ($P < .001$)
Lazowski et al, 1999[36]	Type: Seated ROM Frequency: 3 times/wk Time: 45 min, 4 mo Intensity: low	ROM exercises for the fingers, hands, arms, and legs, vocal exercises, word/memory games, relaxation	Physical function ↓↑ TUG score 23%, ($P < .05$), FIM score 5%, ($P < .05$), lower extremity strength 17%, ($P \leq .001$), shoulder flexibility 21%, ($P < .05$) Cognitive function NA Psychosocial well-being NA
Nagai et al, 2011[37]	Type: Multicomponent Frequency: Daily Time: session time NR, 8 wk Intensity: low	Toe and ankle training with towels and beanbags	Physical function ↑ Quadriceps 0.13 Nm/kg ($P < .05$), FR 3.3 cm ($P < .05$), FES score 1.3 points ($P < .054$) Cognitive function NA Psychosocial well-being ↑ HR-QoL 0.9 points ($P < .004$)
Payten et al, 1994[38]	Type: Multicomponent Frequency: 2 times/wk Time: 20 min, 16 wk Intensity: low, slow, and gentle, 6 reps for each exercise	Seated aerobics in wheelchairs or armchairs, slow rhythmic exercises, orientation tasks, music, colorful balls, balloons, and scarfs, skipping rope, parachute	Physical function NA Cognitive function ↑ Attention span 75% participants improved Psychosocial well-being ↑ HR-QoL 83% participants improved, socialization 83%, participation 83%, attention span 75%, sleep pattern 84%, depression 10%
Pomeroy, 1993[39]	Type: Multicomponent Frequency: 3 times/wk Time: 30 min, 6 wk Intensity: moderate	Music and movement, body awareness, major joints movement, massage techniques, gymnastic ball exercises, functional mobility training	Physical function ↑ ADL mobility 1.37 points ($P < .043$) Cognitive function NA Psychosocial well-being NA
Thurm et al, 2011[40]	Type: Multicomponent Frequency: 2 times/wk Time: 45 min, 24 wk Intensity: moderate, exercises gradually increased in level of difficulty and complexity	Strengthening, coordination, balance, flexibility, and stamina, mental journeys, repeated memory aids, pool noodle	Physical function → ADL, IADL Cognitive function ↑ ADAS-Cog F 10.76 ($P < .007$) Psychosocial well-being → GDS-15
Rieping et al, 2019[41]	Type: Two multicomponent programs Frequency: 2-3 times/wk Time: 45 min, 14 wk Intensity: moderate, adapting the levels of resistance, increasing movement complexity	CAE: Aerobic mobility, dynamic stretching, body weight exercises CSE: elastic-band muscle strength resistance training, stretching and breathing	Physical function ↑ Arm curl CAE 32% ($P < .05$), moderate ES, chair stand CSE 27% ($P < .05$), moderate effect size, TUG CAE 23% ($P < .05$), moderate ES, FES CAE 53% ($P < .05$), moderate ES, IADL CSE 13% ($P < .05$), moderate ES Cognitive function NA Psychosocial well-being NA

ADAS-Cog, Alzheimer Disease Assessment Scale–Cognitive Subscale; BBS, Berg Balance Scale; BP, systolic blood pressure; BSRS-5, Brief Symptom Rating Scale-5; CAE, chair aerobic exercise program; CSE, chair strength exercise program; DST, distal skin temperature; ES, effect size; FES, Falls Efficacy Scale; FIM, Functional Independence Measure; FR, functional reach; GDS-15, Geriatric Depression Scale–15; (I)ADL, (instrumental) activities of daily living; ITT, inspiratory threshold training; MMSE, Mini-Mental State Exam; NA, not assessed; NR, not reported; PPT, physical performance test; RM, respiratory muscle; TUG, timed up and go test; YRT, yoga respiratory training. Intensity: If not reported, intensity levels were judged based on information in text following the FITT principles.

Characteristics of the Exercise Programs

Intensity

Four studies identified the intensity of the intervention as low[37,38] or moderate.[40,41] All other studies only described the exercises without defining intensity. To evaluate the intensity of all included studies, the recommendations and principles of dose adjustment displayed in Table 1 were used. Four studies were identified as low[35–38] and 6 studies as moderately[32–34,39–41] intense. Five studies[32–34,40,41] and the control group of 1 study[38] used moderate intensities and reported the usage of progression. Because of the insufficient reporting in some of the studies, it was not possible to determine a clear dose-response relationship.

Duration, time, and frequency

Time and frequency ranged between 20 and 60 minutes for one training session and 2 to 7 sessions per week. Intervention duration ranged from 6 weeks to 6 months (Table 3). No clear dose-response relationship could be determined.

Types of control group interventions

Nine studies[32–37,39–41] comprised a control group, of which 7 took part in usual care.[33–35,37,39–41] One study[32] conducted a recreational group as control group with several nonexercise leisure activities. All usual care activities and nonexercise control groups showed no effect on measured outcomes. One study[36] compared a CBE program with ROM exercises to a multicomponent exercise program with both seated and standing/walking exercises. Although the CBE group only improved shoulder strength and deteriorated in hip strength and mobility, the multicomponent group improved mobility, balance, flexibility, knee, and hip strength. One study[41] compared 2 different CBE programs and a usual care control group.

Methodological quality

None of the studies reached an excellent quality level (Supplementary Table 3). Three studies were rated as good,[33,34,41] whereas the remaining studies were rated fair or poor. Only 2 studies[34,41] reported a power analysis. Two studies[33,40] gave a sufficient report about the intervention characteristics. No association between methodological quality and intervention efficacy could be determined.

Discussion

The aim of this systematic review was to summarize the current evidence on CBE interventions for nursing home residents. We attempted to find out whether and how CBE interventions are able to improve or sustain physical functioning, cognition, and psychosocial well-being. Ten studies that met the inclusion criteria of the review could be found.

Efficacy of CBE Interventions

Nine of 10 studies reported significant improvements in at least 1 of the measured outcome domains (physical function, cognitive function, and well-being). Seven of 10 studies had a focus on physical performance and found improvements in (instrumental) ADL,[39,41] lower body strength,[37,41] upper body strength,[36,41] hand grip strength,[34,36] hip extension,[34,36] respiratory muscle strength,[33,34] arm muscle endurance,[34,38,41] joint flexibility,[33,36,38,39] and functional reach.[36,37] These improvements can promote functional abilities and prevent functional decline and therefore contribute to a better performance in ADL for both ambulatory and wheelchair-bound residents.[42] Regardless of the positive effects, a high degree of heterogeneity across study samples was observed. Nonetheless, CBE interventions appear to be feasible and beneficial for nursing home residents.

The findings of the review regarding physical functions of the upper body (eg, shoulder flexibility, functional reach, and hand grip strength), cardiorespiratory fitness (eg, BP and lung capacity) and cognition are in concordance with results from studies that included walking exercises in frail and multimorbid but ambulatory nursing home residents and found improvements in physical function[9,12–14,43–47] and ADL.[13,14] However, the lack of direct comparison between CBE and interventions including upright exercises does not enable conclusions about the relative efficacy of these training paradigms. With regard to the functions of the lower extremities (timed up and go test performance and lower extremity strength), a multicomponent program with standing and walking exercises is clearly superior to a CBE program with seated ROM exercises.[36] This demonstrates the importance of task-specific training with increased load due to carrying the own body weight and the better transfer of standing and walking exercises into ADL. However, 3 studies[32,37,41] demonstrated an increased lower body performance (quadriceps strength, chair stand, timed up and go test) following a multicomponent CBE program without walking exercises, indicating a transfer from seated to mobility tasks.

Three studies[34,35,39] only including residents unable to walk improved physical functions (eg, cardiorespiratory fitness,[35] ADL,[34,39] upper body strength[34]). Two[34,39] of these studies administered multicomponent CBE programs. This indicates that immobile residents benefit from participating in group-based CBE programs. The findings are also in line with existing evidence from community-dwelling older and frail people, demonstrating that multicomponent programs targeting several aspects of functioning are best for improving various dimensions of functioning. However, ambulatory residents may have other needs for a targeted training (fall prevention, increased life space) than residents who are unable to walk [upper body strength, (instrumental) ADL]. Therefore, it could be helpful to separate groups according to functional abilities for conducting targeted and needs-based multicomponent interventions.

One of the included studies[40] showed that motor exercises combined with mental and memory exercises were effective in improving cognitive functioning. Other promising motor-cognitive interventions are training under dual-task conditions[48] and exergaming[49–52] which demonstrated benefits for improving physical and cognitive performance in older adults, including people with dementia and residents from retirement villages and nursing homes. The effects of these interventions incorporated in CBE have not been sufficiently investigated yet. However, a small-scale RCT in community-dwelling older people demonstrated improved gait performance following a seated dual-task stepping training compared to stepping under single-task condition.[53]

It appears to be helpful to use motivational equipment,[31] such as colored scarves, weights, balls, parachutes, or music.[54] In the current review, the use of motivational equipment was reported to be easily implemented and a way to ensure regular participation. As no appropriate control group existed (ie, no motivational equipment), additional studies are required.

Despite low mobility and high frailty levels, nursing home residents have health-related resources that CBE interventions are able to improve.[2,55–59] Because of the wide spectrum of effects of exercise in a biopsychosocial context, every nursing home resident should be given the opportunity to participate in an evidence-based training program several times a week.[60]

Exercise Characteristics

Assessing the intensity and measures of progression is important to provide an adequate stimulus for physical adaptation. The current analysis revealed that for beneficial effects on physical functions, interventions using low and moderate intensities are feasible. Unfortunately, only 2 studies assessed the intensity level using the Borg Scale[33,41] and 5 studies[32–34,40,41] reported the use of progression. The remaining studies only described the exercises without any specific information about how they defined and assessed intensity. A reason for this insufficient reporting might be the lack of knowledge on how to adjust intensity as specific guidelines are lacking in this vulnerable population. Current exercise guidelines for older adults are certainly more appropriate for community-dwelling older adults and for those who are dependent in ADLs but still able to ambulate than for institutionalized nursing home residents, including those who are unable to walk.[31,61] CBE guidelines for wheelchair-bound nursing home residents are missing. The fear of overloading and subsequent injuries when applying similar intensities as for healthy older adults might be another reason for this lack.[62] Additionally, it is sometimes wrongly assumed that because of high frailty levels people would not benefit from an exercise intervention.[42] Thus, simple repetitive seated ROM exercises without progression are sufficient when only aiming at social participation. However, it has become increasingly clear that even institutionalized and frail older adults tolerate CBE with moderate[57] or even higher intensities[58,59] and can improve physical function and ADL performance.[2,55,56]

Despite a broad acceptance among health care professionals for the need of training in old age, many aspects of dose-response relationships have yet to be clarified.[26] This research gap has already been criticized in previous studies.[63,64] The current review aimed at closing this gap and contribute to specific guidelines. Although dose parameters varied greatly, successful interventions reported a frequency of 2 to 5 times per week, 30 to 60 minutes per training session, for 6 weeks to 6 months of intervention time with low or moderate intensity. This is in concordance with recommendations of the taskforce report on exercise and physical activity for ambulatory nursing homes residents, which suggests moderate intensity, 35 to 45 minutes for 2 times per week or more often for residents with higher fitness levels.[31] However, because of the large heterogeneity, weak reporting, and the risk of being underpowered, dose-response relationships could not be clearly identified. This issue urgently requires further study.

Limitations

We need to acknowledge some limitations. First, only few studies were included based on our inclusion criteria. Most of the excluded studies consisted of interventions of standing and walking exercises to prevent falls, not enabling us to judge the seated program components with regard to their effects on relevant outcomes. However, we believe that excluding immobile residents from most studies has led to a gap between research and practice. This review is the first to summarize relevant information for CBE in nursing homes and thus helps to implement interventions that are suitable for residents who are unable to walk. However, only 3 studies included only residents who were unable to walk. Therefore, this review cannot provide an answer to the question whether the efficacy of CBE differs when comparing mobile and immobile residents, for instance because of differing reserve capacities. Second, because of the low number of studies, the variety in sample and intervention characteristics, choice of control conditions, and poor reporting, it remains unclear what the optimal content and dose parameters are for improving health-related factors in nursing home residents. Many excluded studies focus on the effectiveness of training programs for leg strength, balance, and mobility, without providing precise information on training modalities, for example, sitting or standing exercises, dose, and intensity. A consensus definition for CBE is also lacking.[24]

Finally, only studies published in English or German were included. However, none of the potentially eligible titles, abstracts, or full texts were excluded because of language.

Conclusions and Implications

Overall, this review finds evidence that CBE interventions have a positive effect on physical and cognitive functions as well as psychosocial well-being in nursing home residents, including those who are unable to walk. For beneficial effects on multiple outcome domains, interventions should administer multicomponent exercises and include task-specific and motor-cognitive exercises. The current findings complement the existing exercise guidelines for ambulatory residents; however, the lack of separation of mobile and immobile residents in analyses limits the specificity of what can be recommended. High-quality RCTs with sufficient power focusing on specific CBE modalities, separating analyses by mobility status, and adjustment of intensity and progression are needed to provide more targeted and evidence-based guidelines.

Supplementary Data

Supplementary data related to this article can be found online at https://doi.org/10.1016/j.jamda.2020.09.042.

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Anhang D: Publikation III

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ORIGINAL ARTICLE

Can cognitive-motor training improve physical functioning and psychosocial wellbeing in nursing home residents? A randomized controlled feasibility study as part of the PROCARE project

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Abstract

Background A multi-component training program holds promises for the elderly, but still has to be tested on its feasibility and effect in nursing homes.

Aims The aim of this study was (1) to design a multi-component training program which improves physical functioning and psychosocial wellbeing and (2) to evaluate the feasibility of this intervention in nursing home residents.

Methods This study is a two-arm, stratified-randomized controlled feasibility trail. Twenty-four nursing home residents (aged 83.7 ± 6.4, 21 women) were divided into an intervention and a waiting-list control group. The intervention group completed a multi-component training (including dual-task, dynamic balance, endurance and strength exercises) for 16 weeks (twice per week for 45–60 min). Primary outcomes were lower extremity functionality (SPPB), gait performance (GAITRite), health-related quality of life (SF-12) as well as life satisfaction (SWLS).

Results Life satisfaction (SWLS) and physical functioning (SPPB) increased in the intervention group after training whereas the control group showed a decrease. Gait parameters could only be analyzed for $n = 5$ participants of the intervention group and $n = 2$ of the control group and showed no time differences for the intervention group. The mean number of participants was 12.5 ± 1.9 per session (attendance ranged between 66% and 90%).

Conclusion A multi-component training seems (1) to lead to clinically relevant improvements in physical functioning as well as in psychosocial wellbeing and (2) to be feasible and well accepted in nursing home residents. Nevertheless, the complexity and progression of the program as well as the testing protocol have to be adapted. Further research should test the effectiveness of this adapted program in a larger sample size.

Keywords Nursing home · Aged · Frail elderly · Training · Multi-component training · Dual task · Exercise

Introduction

Demographic changes force countries worldwide to deal with an increasingly aging population and corresponding policy changes are being discussed on all levels [1, 2]. The incidence rates of age-associated diseases such as cancer, cardiovascular and neurodegenerative diseases, as well as diabetes are rising, leading to further demands of treatment and long-term care due to cognitive and functional impairments [3, 4]. Hence nursing home residents are increasingly characterized by multimorbidity [5, 6].

The aging process is complex and heterogeneous. However, there are strong associations between age and cognitive decline [7–9], as well as associations between cognitive changes and diminished gait stability [10, 11], balance

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control [12, 13], risk of falling [14] and navigation difficulties [15] in older adults. As potential underlying mechanisms of motor performance, it is proposed that motor aspects of performance, like walking, are increasingly in need of cognitive resources with advancing age [16]. Aging further is accompanied with decrements in physical functioning expressed in diminished physical fitness and muscle strength which often result in lower grip strength [17], frailty [18] or falls [19, 20]. Respectively, reduced scores of the activities of daily living (ADL's) [21], the instrumental activities of daily living (IADL's) [22] or (lower extremity) physical performance [23] are common in nursing home residents.

In light of the challenges of an aging population, many European countries have taken political actions to enforce prevention measures and interventions on healthy aging [24]. Studies show that exercise interventions, for example in rehabilitation settings, on different intensity levels can prevent or slow the decline in the performance of everyday activities [25–27], functional performance [28, 29], cognitive performance [30, 31], depressive symptoms [32], and improve quality of life [33–35].

Nevertheless, exercise intervention studies conducted in the setting of nursing homes with very-old populations are still rare, and results vary [36, 37]. A few studies indicate a positive effect of multi-component exercise interventions on physical functioning even in the very-old and frail population in geriatric care [28, 38–44], whereas these results could not be obtained in others [33]. Hereby, multi-component training programs (e.g., strength training combined with gait training [45] or strength training combined with functional training [46]) show superior effects to single component training. In a 3-month multi-component exercise intervention focusing on strength, balance, stretching exercises, and walking training, a significant improvement in physical functioning was achieved in nursing home residents [38]. Other studies showed no superior effect of exercise interventions in comparison to control groups with regard to cognitive outcomes and dementia [30, 47, 48] and heterogeneous effects of exercise interventions on psychosocial wellbeing [34, 35, 49]. According to a systematic review by Horn et al., [37] there is a lack of adequate description of the conducted exercise interventions to transfer existing study results with older adults into the nursing home setting. Further, there is a lack of studies addressing the association between motor and cognitive decline.

That is, only a few studies have incorporated dual-task (DT) elements in training programs for long-term residents in nursing home settings [50, 51]. Nevertheless, DT elements such as walking tasks combined with different cognitive tasks and a variable task prioritizing training that includes shifting of attentional control have shown to be effective in improving cognitive-motor performance in older adults [52] and even more effective than single task strength training or no training in older adults [53]. This seems to be particularly true when a progression in DT difficulties is emphasized in the training program [52, 54, 55]. In comparison to a standard exercise intervention, a cognitive task-managing motor learning intervention which applied goal oriented and repetitive exercises enhanced walking performance in adults over the age of 65 who had subclinical gait dysfunctions. The motor learning exercise program included both stepping and walking patterns [56]. Moreover, positive effects were found for participants with mild cognitive impairments [51].

In summary, previous effective training intervention studies have combined different training aspects such as muscular strength training, endurance and balance exercises as well as gait training in multimodal programs. From findings in community-dwelling older adults, it appears that especially exercises including both, motor and cognitive components, such as DT walking should be included into the training [24, 53].

To our knowledge no prior study has assessed the feasibility nor the appropriate exercise combination of such a training program in long-term residents of nursing homes.

The aim of this study was (1) to design a targeted multi-component training program applying a bottom-up approach [57] which may improve physical functioning and psychosocial wellbeing and (2) to evaluate the feasibility and preliminary efficacy of this training intervention compared to a control group in very-old nursing home residents. The primary outcomes were lower extremity functionality (SPPB), gait performance (spatio-temporal parameters in the GAITRite), health-related quality of life (SF-12) as well as life satisfaction (SWLS). Secondary outcomes were activities of daily living (Barthel Index), hand grip strength and cognitive functioning (MoCA).

Methods

The extended CONSORT statement [58] was used as a guideline to generate this feasibility study.

Study design and participants

A newly developed 16 week-multi-component training program with motor and cognitive components for nursing home residents was designed as part of the PRevention and Occupational health in long-term CARE project (PROCARE). Recruitment and eligibility was based upon consultation of senior management, nursing staff and nursing documentation.

Twenty-four long-term nursing home residents (21 females, 83.7 ± 6.5 years old, cf. Table 2) between 72 and 100 years of age were recruited in a nursing home located in the city of Hamburg, Germany. All nursing home residents or their legal guardians gave written informed consent prior to the study enrollment. Inclusion criteria were (i) willingness to participate, (ii) the ability to understand and execute simple instructions, (iii) the ability to walk with or without a walking aid for 10 m, and (iv) the ability to participate in group activities. Eligibility criteria were assessed by the senior management, nursing staff and nursing documentation (cf. participant characteristics in Table 2).

Half of the included study participants were allocated in a stratified-randomized way (gender, age and SPPB) by an independent senior researcher via drawing of lots to (a) a 16 week exercise intervention group or (b) a waiting-list control group who received 16 weeks of usual care and could start the same exercise intervention after 16 weeks.

The study was approved by the Ethics Committee of the Hamburg Chamber of Physicians (registration number PV5762).

Description of the development of the intervention program

The development of the tailored intervention followed two steps.

(1) qualitative analysis of the requirements for a tailored exercise program expressed by the nursing home residents and

(2) integration of evidence based previous exercise programs and their adaptation to an old and functionally impaired target group.

Step (1)

During the first step, qualitative guided interviews were conducted with five residents (four women and one man) of the facility. The interviews had an average duration of 18 min and integrated a total of 17 questions assessing four main domains: the resident's (I) activities of daily living, (II) need of support, (III) participation in social activities, as well as (IV) their expectations and wishes regarding a training program.

The interviewee's daily routine included listening to music and audio books, knitting, drawing and going for a walk. Furthermore, the current need for support in everyday life, such as dressing, showering and immobility was reported. Three residents expressed discontent about unwanted dependency and the attempt to perform activities like personal hygiene as autonomous as possible. Two residents were happy with the help provided by the facility's nurses. Social contacts and activities were mainly realized through group activities (religious service in the facility, singing and chair gymnastics). Further, the interviewees expressed a great interest in music and in playful, group-based exercises. In summary, a desire for more social contacts and interlocutors and the need for more independence in activities of daily living were main themes throughout the interviews.

Step (2)

The multi-component training program was developed based on wishes, needs and comments of the nursing home's residents expressed in the interviews (cf. Step 1) and previously published exercises that have proven to be advantageous for cognitive-motor functions in older adults in the community and in need of care [26, 52, 53, 59–65]. The exercise program consisted of 32 sessions for a period of 16 weeks. One training session lasted 45–60 min and took place twice a week.

The program focused on situations of a resident's daily routine, which are commonly associated with an increased risk of falling. Hence exercises like starting, stopping, managing obstacles, turning and brisk walking were trained. During these exercises, participants had to change their focus of attention and task prioritization and switch between tasks under single- and dual-task conditions. Exercises for dynamic balance, endurance and strength were also integrated (cf. Table 1).

To meet wishes and demands expressed by the target group, music as well as playful and motivational equipment (e.g. balls, balloons, scarfs and parachutes) were used.

Training sessions were divided into five parts:

1. 5–10 min warm-up and mobilization – seated and standing (e.g., range of motion exercises for hip, shoulders, knees, wrists and ankles),
2. 10 min balance, coordination and cognitive exercises (e.g., standing or sitting balance, bodyweight shifting, cognitive-motor games with group interaction including signs and pictures),
3. 20 min aerobic exercises while walking or sitting (e.g., under different single and dual-task conditions),
4. 10 min strength exercises (e.g., chair rises, trunk and upper body exercises with additional weights, functional lower-limb exercises),
5. 5–10 min cool down (e.g., relaxing and stretching exercises).

As recommended by the American College of Sports Medicine [66], the exercise program was continuously adapted to the residents' capacity by a certified trainer, was organized as a progressive challenge and followed the F.I.T.T. (Frequency, Intensity, Time, and Type of exercise) principle (cf. Table 1).

Table 1 Progression of tasks, DT and difficulty over the course of the training intervention

	Level 1	Level 2	Level 3	Level 4
Balance/ Cognition	Semi-tandem and tandem stand	+ One leg stand w. swinging of the right and left leg	+ Raise knees and circle feet	
	Body weight shifting forwards and backwards			
	One leg stand	+ One leg stand "drawing eights" (right and left leg)	+ One leg stand with leg abduction right and left	
	Moving balls clockwise and / or counter clockwise (variation left hand, right hand, both hands, commands w. change of directions)	+ Dual Task: additional naming of words with the starting letter F	+ Dual Task: counting backwards by 2's from 100	
	– Throwing or kicking a ball towards each other (progression: count throws and kicks, call each other's names)		– Throwing balloons, playing crisscross without touching the ground, counting touches of the ground	
	– Active stories / cognitive-motor tales (incorporated movement into stories)			
	– Memory games: e.g. „I packed my suitcase with… " or showing pictures with different objects to remember			
	– Stroop-task (color-word interference)			
	– Orientation exercises by showing different rooms of the facility on photos			
	– Throwing scarfs in the air and catching with the same or opposite hand			
Strength	– Bending knee or stretching leg, 20 repetitions	– Bending and stretching knee, 2×20 repetitions	– Bending and stretching knee, 3×15 repetitions + weight cuff, 1-2 kg	– Squats 2×20
	– Rowing with rod, 15 repetitions	– Rowing with rod, 2×15 repetitions	– Rowing with rod, 3×15 repetitions	– Rowing with rod, 4×15 repetitions
	– Rotation of upper body, 10 repetitions	– Rotation of upper body, 2×15 repetitions	– Rotation of upper body, 3×15 repetitions	
	– Strength exercises with the towel (eg. compress between knees) 10×3 s	– Strength exercises with the towel, 10×5 s	– Strength exercises with the towel, 15×5 s	– Strength exercises with the towel, 20×5 s
		– Biceps Curls 1–2 kg, 1×10 repetitions	– Biceps Curls 1–2 kg, 2×10 repetitions	– Biceps Curls 1–2 kg, 3×10 repetitions
Walking (Endurance)	– 15 m walking in preferred walking speed, back and forth (2 lanes)	+ Carrying a heavy shopping bag 1-2 k	+ Abrupt starting and stopping, walking in response to commands of the trainer	+ Acting in reaction to signs (e.g. change of direction, stop and go)
	– Brisk walking	+ Stepping over a tap board	+ Carrying plastic cups back and forth	+ Walking stairs
	– Long steps	+ Slalom around carpet tile	+ Reading signs with number series	
	– Sitting down and standing up, 5 repetitions		+ Walking sideways along the wall	

The training was administered by a certified exercise therapist in a room located in the nursing home. To realize the intended progression in the training program, the instructor adapted intensity and type of exercises (designated difficulty levels in the developed program, cf. Table 1) to participants' performance.

Outcome measures

The measurements addressed the main aspects of feasibility and two key domains of clinical outcomes: physical functioning and psychosocial wellbeing. Physical and general health outcomes were collected at baseline and after 16 weeks of training (post training). Outcome assessors and data analysts were blinded. A week of testing was scheduled before and after the intervention period. Testing took place in the nursing home facility between 09:30 and 11:30 am. Each study participant was tested on the same day at the same time before and after the intervention period. Nursing home personnel accompanied the resident to the room of testing, where residents were again informed on all measurements and instruments before they started the tests.

Feasibility

This study aims at assessing the feasibility of (i) the newly developed intervention and (ii) the measurement protocol.

Feasibility of the intervention was determined by the certified trainer examining adherence of participants to each intervention session (session completed, and tasks completed within each session) as well as the average time taken for each session of training by an adherence list and notes taken within each session.

Participant acceptance of the intervention was examined by qualitative participants' group feedback and feedback of the nursing personnel at the end of the 16-week intervention. Feasibility of the measurement protocol was determined by completion of measurements of all outcomes in all participants.

Primary outcomes

Lower extremity functionality including balance, gait speed, and leg strength was tested with the *Short Physical Performance Battery* (SPPB) [67]. The SPPB is scored from 0 to 12 and is composed of three tests: balance, gait speed and chair stand. All subtests are scored from 0 to 4 with higher scores representing better physical and functional ability.

Gait performance was assessed by measuring step length, step width and gait speed on a 7.92-m track with the *GAITRite*: CIR Systems Inc., Clifton, NJ, USA. Participants received one practice trial and then data was recorded on the second trial. The same assessor recorded all measures for each participant and participants were given adequate rests between tests. Participants walked with shoes and were allowed to use their walking aid if required. Data was analyzed using the GAITrite 4.5.5 software.

The short form of the *Health Survey* (SF-12) [68] was used to examine the health-related quality of life of the nursing home residents with the physical and mental component summary score.

Global cognitive judgments of satisfaction with one's life was assessed with the German translation of the *Satisfaction With Life Scale* (SWLS) adding the five items to a sum score [69].

Secondary outcomes

To evaluate independence in performing basic activities of daily living (ADL) the *Barthel Index* [70] was recorded. Ten items were rated on a scale from 0 to 15 points depending on the item. Total possible scores range from 0 (totally dependent) to 100 (fully independent).

Hand Grip Strength was assessed with a hydraulic hand dynamometer (JAMAR, model 5030J1, J.A. Preston Corporation, Clifton, NJ). Three trials with each hand were executed to assess the maximum hand grip strength of the dominant and non-dominant hand (best trial).

The German version of the *Montreal Cognitive Assessment* (MoCA) was used as a screening tool of global cognition, assessing several cognitive domains, like short-term memory recall, visuospatial abilities, executive functions, attention, concentration and working memory, language and orientation to time and place [71]. An overall score is calculated ranging between 0 and 30 (scores above 26 are considered cognitively healthy).

Statistical analyses

Descriptive data are presented as percentage, mean and standard deviation.

Statistical comparison pre and post training intervention of only those participants who completed both baseline as well as post training testing, was performed using Wilcoxon tests ($\alpha < 0.05$) for the analyses of primary and secondary outcomes. Furthermore, Mann–Whitney *U* tests were used to detect differences between intervention and control groups ($\alpha < 0.05$) at pre- and post-test for primary outcomes. Following the recommendations of Blanca et al. [72], we used a mixed ANOVA for all primary outcomes. Effect sizes were calculated using Cohen's d in all between-subject (group differences) and Cohen's d_z in all within-subject (time differences)

Fig. 1 Flowchart CONSORT-Statement

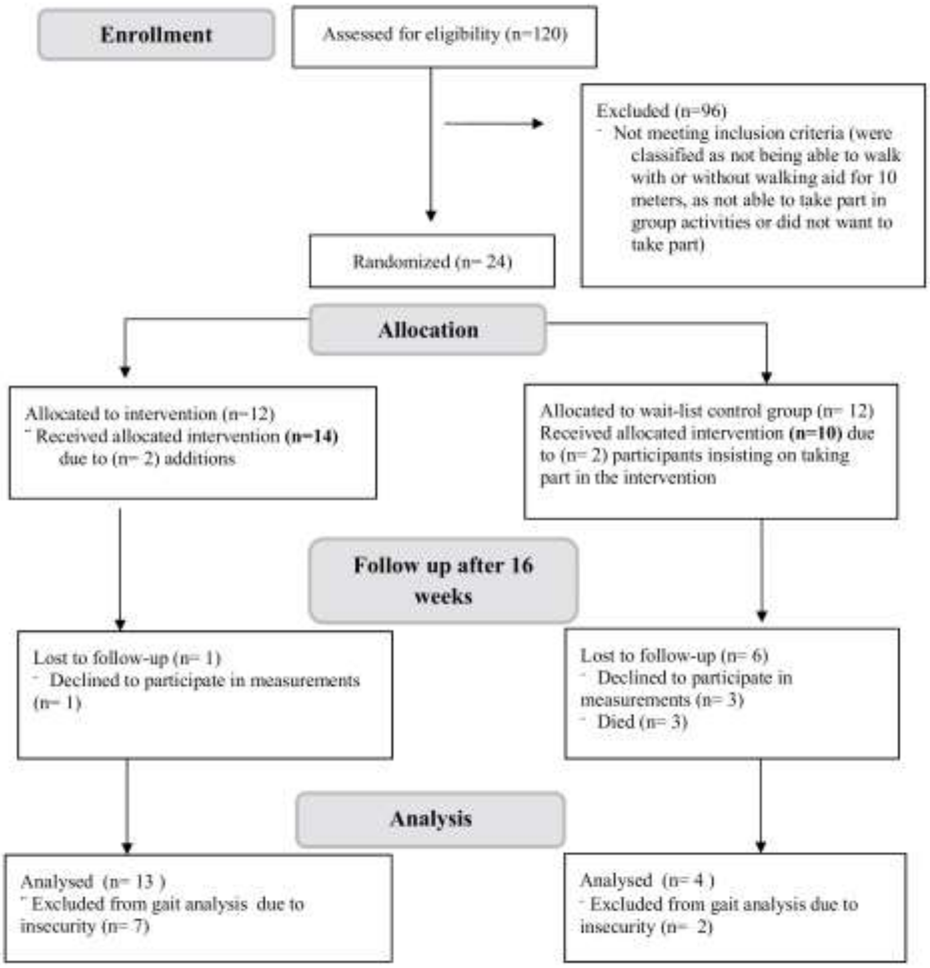

Table 2 Baseline characteristic of participants and dropouts, differences between groups using Mann–Whitney U Test (*p*)

	Intervention group ($n=14$)	Control group ($n=10$)	Statistics *p*	Dropouts ($n=7$)	Statistics *p*
Females, *N* (%)	12 (85.7)	9 (90)		6 (85.7)	
Age (mean ± SD)	83.6 ± 7.3	83.8 ± 5.7	0.80	85.6 ± 8.5	0.62
Weight (mean ± SD)	63.3 ± 9.6	68 ± 9.2	0.40	68.8 ± 9.3	0.29
Barthel index (mean ± SD)	85 ± 12.4	75 ± 16.6	0.12	75 ± 15.5	0.21
SF-12 mental health (mean ± SD)	49.8 ± 12.6	51.1 ± 12.4	1.00	52.8 ± 10	0.62
SF-12 physical health (mean ± SD)	47.8 ± 9.9	40.6 ± 14.3	0.28	38.3 ± 13.3	0.13
SWLS (mean ± SD)	21.62 ± 8.7	16.8 ± 12.2	0.29	9.2 ± 8.5	0.00
SPPB (mean ± SD)	5.9 ± 3.0	5.7 ± 2.6	1.00	4.6 ± 1.3	0.40
Grip Force right (kg) (mean ± SD)	10.8 ± 6	12.3 ± 6.7	0.63	13.1 ± 6.6	0.45
Grip Force left (kg) (mean ± SD)	9.8 ± 4.7	8.8 ± 3.3	0.35	8.9 ± 2.6	0.58
MoCa (mean ± SD)	11.1 ± 6.8	11.6 ± 11.9	0.79	8.3 ± 4.3	0.20

comparisons. The statistical analyses were performed with IBM SPSS Statistics (Version 25.0. Armonk, NY; IBM Corp.).

Results

Twenty-four long-term nursing home residents participated in the feasibility study (cf. Fig. 1). Subject characteristics are presented in Table 2. Residents were stratified randomly (gender, age and SPPB) into two groups of twelve. Nevertheless, two participants of the control group insisted on taking part in the intervention and are therefore to be found in the baseline data of the intervention group ($n = 14$; control group $n = 10$). Furthermore, not all participant's data could be fully analyzed post intervention (cf. Table 2). Besides seven dropouts throughout the study, we faced issues with the measurement protocol and missing data.

There were no significant differences in any of the baseline characteristics between the intervention and the control group (cf. Table 2). Nevertheless, the seven dropouts throughout the 16 weeks study (of which six were in the control group) showed a significant lower score in the Satisfaction With Life Scale (SWLS) at baseline (cf. Table 2).

Feasibility

Adherence

At the beginning of the first session we had four unexpected participants who wanted to join the group. Two of them were randomized into the control group and did not agree to stay on the waiting list. Two other participants joined in spontaneously but did not agree to take part in the pre and post measurements. Due to ethical reasons we did not exclude them from the training sessions. Residents were accompanied by the nursing personnel to the intervention room, if assistance or a reminder was wanted and needed.

Overall, the intervention group had the opportunity to take part in 32 sessions. The mean participating rate was 12.5 ± 1.9 participants per session (the individual participating rate ranged between 66 and 90% over the intervention period) and only one person did not finish the training intervention. Absence to the intervention was due to medical reasons only. Adherence was assessed by the trainer using a time log.

Performance quantity and quality of the intervention

A total of 45 min training duration was feasible for this target group. There were no adverse events related to the intervention reported. However, there were episodes of muscles soreness reported by some participants (leading to unplanned resting periods within the training session). In addition, (1) some motor exercises (walking exercises, strength and balance) were left out by participants stating that they felt too difficult. Furthermore, (2) difficulties due to the complexity of cognitive tasks were reported.

(1) Motor performance

The program integrated a progressive increase of the distance walked during training up to 14 laps (cf. Table 1). A distance longer than fourteen gait laps could not be realized due to reasons of fatigue (> 70% of the participants) and because additional time within the training sessions to organize the walking tasks was not planned. Therefore, the walking distance and the progression of the DT complexity were reduced. Moreover, some of the walking tasks needed to be deleted due to environmental and safety aspects (e.g., walking side wards and stepping over obstacles).

The combination of walking and strength training was rated as too exhausting. Therefore, the strength exercises were conducted while sitting after the walking performance. The weights of the strength part were too heavy for half of the participants at the beginning of the intervention. Moreover, the application of the weight band required a lot of time helping the participants. They were replaced by exercises using gravity and one's body weight (e.g., standing up for leg muscle strength).

At the beginning of the program (session 1 to 6) motor coordination, balance performance and shoulder mobility of the participants (50%) were reported by residents as being too challenging and leading to problems in realizing the correct movements of the instructed exercises. These exercises needed additional supervision, e.g., tasks using air balloons.

(2) Cognitive complexity

Cognitive-motor games were only feasible when performed at a low level of complexity and in seated position. Main problems of the participants were difficulties of spatial orientation (25% of participants) and tasks including vision (12.5%) as well as executive function, e.g., DT exercises as counting backwards by 2's from 100 (50–90%). However, the study participants tolerated basic mental tracking tasks (e.g., naming animals, counting backwards by 1's).

Therefore, task complexity while walking was reduced. Cognitive training was realized through cognitive-motor tales at the beginning of training sessions, i.e. a story of how to take a shower while adding the required movements.

Overall, the resting periods needed within the program were underestimated. This aspect led to a reduction of the total amount of exercises to be able to include flexible resting periods.

The application of music was recognized to be positive and helpful. Thus, periods with rhythmic tasks including clapping and tapping were integrated.

Acceptability

To operationalize the acceptability of the training program, participants were asked to give a qualitative feedback after the training sessions. Most participants, who completed the training, agreed that the program was an overall positive experience. They rated the novelty of the exercises, achieved gait performance as well as the qualification of the instructor as very positive.

In addition, the nursing personnel qualitatively (subjectively) reported that participants of the intervention gained more mobility for their daily activities. Moreover, they noted a positive attitude towards the training program with participants looking forward to and impatiently waiting for the next training session and thus rated acceptability as high.

As a result of the study, nursing home staff permanently implemented the training into the facility's weekly program.

Feasibility of the measurement protocol

The measurement protocol was extensive to obtain as many information as possible on different dimensions of physical functioning and psychosocial wellbeing. Whereas the questionnaires and the SPBB were applicable and generally well accepted in the nursing home residents, the measurement of gait parameters at t2 was difficult (cf. Table 3). The acceptance and feasibility of gait measurements was low in the control group. Whereas we could complete the assessment of gait parameters in five out of a potential of 14 nursing home residents in the intervention group after 16 weeks of training, only two participants in the control group fully completed measurements after 16 weeks of waiting.

Effects on outcome measures

Primary outcomes

The intervention group showed an increase in the *Short Physical Performance Battery* (SPPB) scores as well as in the *Satisfaction with Life Scale* (SWLS) scores after 16 weeks of training whereas the control group showed a non-significant decrease (cf. Table 3). Statistical comparisons of primary outcomes (SPPB, SWLS, SF-12 and gait parameters) pre and post training intervention of only those participants who completed both baseline as well as post training testing, was performed using a Wilcoxon test. Nevertheless, these changes did not reach any significance, except for gait speed and step length (for $n=5$ participants). Changes in gait parameters over 16 weeks of training also show large effect sizes.

Gait parameters during the preferred walking speed condition could only be analyzed for $n=5$ participants of the intervention group and $n=2$ of the control group. Differences between intervention and control group at pre- and post-test for gait parameters could therefore not be analyzed statistically sensible but are still reported in Table 3 for the sake of completeness.

As shown in Table 3, the intervention group showed less decrement in walking performance, especially in gait speed and step width than the control group. These changes were accompanied with a non-significant decrease in the Physical Health score of the *Health Survey* (SF-12) over the period of 16 weeks. The Mental Health scores of the control group improved after 16 weeks whereas the intervention group showed a decline. However, this interaction failed to be significant. Interestingly, using mixed ANOVAs, we found a significant interaction only between measurement point and allocated group for SWLS, $F(1, 10)=10.41$, $p=0.009$, partial $\eta^2=0.51$ (cf. Fig. 2).

Secondary outcomes

With regard to secondary outcomes, there was a decrease in independence in performing basic activities of daily living (ADL) assessed via the Barthel Index in both groups. The decrease over 16 weeks did not reach significance nor were there any significant differences between the groups after training. Grip force increased in the intervention group ($n=12$) from 10.8 ± 6 kg to 14.5 ± 8.5 kg in the right and from 9.8 ± 4.7 to 12.2 ± 6 kg in left hand after 16 weeks of training. In the control group grip force decreased in the right hand from 12.1 ± 5.7 to 11.7 ± 5.7 and increased from 9 ± 3.4 to 11.6 ± 6.4 in the left hand over 16 weeks' time. These changes did not reach any significance.

Discussion

The aim of this study was (1) to design a multi-component training program which improves physical functioning, cognition and psychosocial wellbeing and (2) to evaluate the feasibility of this intervention in nursing home residents in long-term care. Overall, the multi-component exercise program was accepted and the duration of 45 min training twice a week was feasible in the majority of training sessions and well accepted by participants (mean adherence of 75%). It also may be promising in improving physical functioning as well as psychological wellbeing. The score of the SPPB increased by 0.7 points with a small effect size ($d=0.36$) but failed to gain statistical significance. Nevertheless, the program improved the score of the SPPB in a cohort

Table 3 Primary outcomes (mean ± SD) in the intervention and control group at baseline and after 16 weeks of training of participants who completed both measurements (t1 and t2) and non-parametric statistical tests Wilcoxon Test shows significant differences between baseline and post training in the IG (within subject), Mann–Whitney *U* Test calculates differences between the groups post intervention

	n	Baseline IG (mean ± SD)	Post-training IG (mean ± SD)	Wilcoxon Test (*z*-value; *p*-value)	Cohen's *dz*	IG Baseline CG (mean ± SD)	*n*	Post-training CG (mean ± SD)	Mann–Whitney *U* Test (*p*-value)	Cohen's *d*
SPPB										
Total score	12	6.1 ± 3.1	6.8 ± 3.1	− 2; 0.16	0.36	7.0 ± 3.6	3	6.3 ± 4.1	0.73	0.14
Preferred walking speed										
Gait speed (cm/s)	5	0.9 ± 0.4	0.8 ± 0.4	− 0.9; 0.35	0.47	0.9 ± 0.3	2	0.7 ± 0.1	1.00	0.34
Step length (cm)	5	47.9 ± 17.8	41.4 ± 20.5	− 1.8; 0.08	1.24	45.6 ± 6.5	2	37.0 ± 9.5	1.00	0.28
Step width (cm)	5	11.8 ± 2.6	12.1 ± 3.2	0; 1.0	**1.34**	15.7 ± 2.4	2	13.7 ± 1.1	1.00	0.67
Maximum walking speed										
Gait speed (cm/s)	5	1.1 ± 0.5	0.8 ± 0.4	− 2; 0.04*	**1.72**	1.1 ± 0.4	2	0.65 ± 0.1	1.00	0.51
Step length (cm)	5	53.3 ± 21.1	47.1 ± 20.9	− 2; 0.04*	1.43	47.3 ± 10.7	2	43.9 ± 1.8	1.00	0.22
Step width (cm)	5	11.8 ± 2.1	11.4 ± 3	− 0.8; 0.42	0.27	15.1 ± 1.3	2	13.6 ± 1.6	1.00	0.92
SF-12										
Mental health score	10	50.7 ± 13.3	47.4 ± 12.9	− 1.1; 0.26	0.32	45.2 ± 15.7	4	50.4 ± 5.7	0.84	0.3
Physical health score	10	48 ± 10	42.9 ± 11.7	− 1.6; 0.11	0.46	43.3 ± 15.2	4	37.5 ± 13	0.45	0.44
SWLS										
Total score	8	21.1 ± 8.9	23.0 ± 7.5	− 1.2; 0.23	0.42	25.8 ± 9.1	4	19.8 ± 10	0.8	0.36

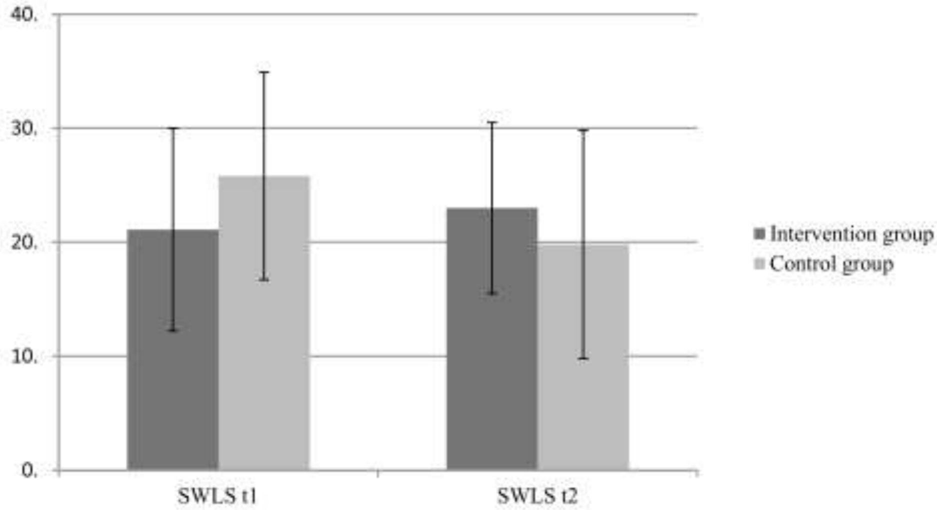

Fig. 2 Satisfaction with Life Scale (SWLS) scores (mean ± SD) at baseline (t1) and after 16 weeks (t2)

of participants that normally shows an overall decrease of physical functioning over time [73, 74] which was—as to be expected—observed in the control group. A small increase and even no deterioration of physical functioning can be considered a success in this population. This interpretation seems consistent with Perera et al. [75] who found an increase of 0.5 points in the SPPB to be meaningful in long-term care. Furthermore, our results are similar to findings of Brustio et al. [55] where a DT training conducted twice a week for 16 weeks showed a statistically significantly better score between baseline and post-test in the Timed Up and Go test (TUG) whereas no significant changes could be found in single task (ST) training or in the control group. Nevertheless, they tested a population an average of 10 years younger (mean age 74.4 ± 3.1) than ours who lived independently. In addition to this, a recent study showed that a 12 week DT multi-component exercise program significantly improved physical function and gait performance in long-term nursing home residents in Spain, with an improvement of even 1.6 points on the SPPB test ($P < 0.001$; $d = 0.99$) [76]. Keeping in mind European differences in care systems and a larger nursing home facility, the results obtained in the present feasibility study seem to be promising for future adaptions of the developed DT program in larger sample size studies in German and international nursing home settings.

Nevertheless, high adherence to the training program was not transferable to the measurement protocol. The gait measurements did not reflect the above mentioned improvement of the SPPB and they did not seem to be feasible in the way they were conducted for this group of nursing home residents (as also indicated by the low participation rate in the gait measurements). A potential reason for the low feasibility of gait assessments post training was the attempt to include as many residents as possible whether they were able to walk autonomously or with walking aids at pre-testing (inclusion criteria was ability to walk with or without walking aid for 10 m based on consultation with the nursing staff and nursing documentation). While testing the residents' gait with the *GAITRite* system, some were only comfortable to walk with help and gait support from the research team. The provided help was difficult to quantify in the analysis. In addition, the data of residents with very low mobility were difficult to capture by the *GAITRite* system and therefore often faulty. To avoid falls and to produce accurate data the research team decided to conduct the gait assessment at t2 only with those residents who were able to walk without help on the day of testing. With these new established inclusion criteria for the gait assessment, there were less residents measured at the t2 assessment and thus less participants included in the data analysis. This seems somewhat counterintuitive since walking exercises during training program were feasible and well accepted. This may be due to the special situation on the testing day, higher motivation or comfort with the known and trusted trainer instead of study personnel on the day of testing or due to an overall longer testing period (testing lasted approximately 60 min) than the duration of the exercise intervention (45 to 60 min). For future studies it might be necessary to integrate a different walking test that also allows to assess the distance that the participants are able to walk, e.g., a modified 6-min walking test, the long distance corridor walk, or sensor based systems [77, 78]. In addition, to gain more insights into gait stability, the walking test should include measures of walking variability under simple single and dual-task conditions (e.g., with adding a verbal fluency test like naming animals). This would also enable the examination of cognitive functions relevant for mobility and falls prevention [79].

Keeping in mind the small sample size, the results of the SWLS may support the observation of the nurses that participants of the intervention group enjoyed the training intervention and might have improved their quality of life. This might result from the decelerated decline of physical functioning in comparison to the control group. However, these results need to be proven within future RCTs with larger sample sizes as well as structured interviews or questionnaires with the nursing staff.

In addition to the interpretation of these results, the test and measurement battery used in this study needs to be reflected critically. Overall, there were too many tests and the whole procedure with a duration of more than 60 min seemed too long for most of the participants. As a result of these experiences we recommend separating the data collection via questionnaires from physical examination tests.

Regarding the intervention itself, organizing a feasible training program for this target group requires the integration of many different aspects. From an exercise science point of view, a training needs a certain duration, frequency and progression to foster cognitive and motor adaptions to the regime [52, 80]. These adaptations can be better guided and controlled if the group of participants is homogeneous. However, this will not be the case in residents of nursing homes. These participants have to deal with numerous health issues that will have an impact on cognitive and/ or motor training adaptations in many ways [73, 74]. At the same time, there will be many participants with gait difficulties in need of walking aids. These participants should not be excluded due to their restricted abilities. In the contrary, especially for this group of nursing home residents a program including walking training should be desirable to maintain physical resources and independence. Therefore, a program presumably resulting in an overall reduction of further decline in cognitive and motor function as shown within our study is feasible for this target group. However, the training program initially designed within this study was too complex to handle all the different requirements of the participants. The described adaptations during the intervention process (reducing the cognitive complexity and walking distance, separating walking and strength exercises) were helpful to gain acceptance by the participants and resulted in a good adherence as well as in a absence of adverse effects. Moreover, the trainers were advised to adapt the progression to the individuals` abilities. In addition, training duration of 45 to 60 min was suitable regarding the cognitive and motor abilities of the participants as well as the time schedule of the facility. The combination of exercise with music was one of the wishes by some participants and was therefore planned to be integrated into all sessions. It has been shown, that music is helpful to reduce the rate of perceived exertion, exercise tolerance and consequently fatigue onset [81, 82]. Nonetheless, we could not consistently use music for all exercises in this program. Due to the heterogeneity of motor, cognitive and cognitive-motor abilities as well as the need for help by the instructor and verbal instructions during complex exercises, music could not be used without endangering safety or feasibility. Separating groups by ability level may be one option to solve this issue, however, might not be feasible in smaller nursing homes.

Changes made in reaction to the results of this feasibility study resulted in a study protocol recently published within the PROCARE project [83].

Limitations

This study has some limitations beyond a small sample size and high dropout rates in the waiting-list control group due to the nature of a feasibility study.

With a mean of 64% female residents in German stationary nursing homes [84], we included an even higher percentage of females in our sample (87.5%) than the German average. This could be a source of selection bias. Some of the chosen tests were not easily applicable in the stationary nursing home setting. Some individuals appeared to be mentally too unstable on the day of testing, indicating the high relevance of day-to-day fluctuations in this setting. Moreover, two participants allocated to the waiting-list control group were fierce on wanting to take part in the intervention group and were ultimately allowed to do so. This may have altered study results.

One major limitation is the small sample size. However, a study by Brustio et al. on a neuromotor training including walking exercises in combination with mental training, was able to recruit 35 participants in a nursing home with 249 inhabitants [85]. The nursing home of this feasibility study accommodates only 100 long-term residents. Therefore, the reached sample size can be judged positively considering recruiting difficulties in this setting.

Conclusion

The results indicate that a targeted multi-component exercise program, designed using a bottom-up approach, might improve or sustain physical functioning and psychosocial wellbeing within residents of nursing homes. This feasibility study indicates less decrements in walking performance, especially in gait speed and step width, and a possible clinical relevant improvement in the *Short Physical Performance Battery* (SPPB) score as well as in the *Satisfaction with Life Scale* (SWLS) score after 16 weeks of training in comparison to the control group, even though these results failed to be significant. No deterioration of physical functioning and cognitive capacity can be considered as a success in this frail and very-old population. Further research should adjust the training program according to the limitations and difficulties discussed in this feasibility study and evaluate the program's effectiveness in improving physical functioning and psychosocial wellbeing including an adequate sample size.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

Statement of human and animal rights The study was approved by the Ethics Committee of the Hamburg Chamber of Physicians. The study was performed in accordance with the 1964 Declaration of Helsinki and its later amendments.

Informed consent The participants or their legal guardians provided written informed content to participate in our study.

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Anhang E: Publikation IV

Cordes, T., & Wollesen, B. (2020). Bewegungsinterventionen zur Förderung der Alltagsfunktionalität für nicht-gehfähige BewohnerInnen in der stationären Altenpflege. In: Wollesen, B., Meixner, C., Gräf, J., Pahmeier, I., Vogt, L., & Woll, A. (Hrsg.), Interdisziplinäre Forschung und Gesundheitsförderung in Lebenswelten. Bewegung fördern, vernetzen, nachhaltig gestalten (1. Aufl., S. 86-91). Hamburg, Deutschland: *Feldhaus* (Schriften der Deutschen Vereinigung für Sportwissenschaft, 289)

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Bewegungsinterventionen zur Förderung der Alltagsfunktionalität für nicht-gehfähige BewohnerInnen in der stationären Altenpflege

Einleitung

Die Zahl der Menschen mit einem Alter über 80 Jahre steigt progressiv an. Mit diesem Anstieg nimmt auch die Zahl an Pflegebedürftigen deutlich zu. Im Jahr 2017 gab es in Deutschland bereits 3,41 Millionen Pflegebedürftige, wovon 0,82 Millionen in Pflegeheimen vollstationär betreut wurden (Statistisches Bundesamt, 2018). Der Zustand von pflegebedürftigen BewohnerInnen der stationären Altenpflege ist gekennzeichnet durch Mehrfacherkrankungen, Gebrechlichkeit, ein hohes Risiko für die Entstehung und das Fortschreiten von Behinderungen sowie den Verlust der Gehfähigkeit (Ferrucci et al., 2004). Dies führt zu starken Einbußen in der Selbstständigkeit bei Aktivitäten des täglichen Lebens (ADL; Covinsky et al., 2003). 59% der BewohnerInnen im Altenpflegeheim haben starke Limitierungen innerhalb der ADL durch motorische und kognitive Fähigkeitseinbußen (Statistisches Bundesamt, 2015). Somit sind sie ohne körperliches Training einem stetigen Abbau physischer Funktionen wie Handkraft, Gleichgewicht und Mobilität ausgesetzt (Masciocci et al., 2019). Dieser Verlust von Alltagsfunktionen steht zudem in Zusammenhang mit einer reduzierten Lebensqualität (Kehyayan et al., 2016).

Studien zu Trainingsinterventionen mit Kraft-, Beweglichkeits- und Gleichgewichtsübungen in der Gruppe zeigen positive Effekte auf die Alltagsfunktionalität von BewohnerInnen im Altenpflegeheim (Crocker et al., 2013). Allerdings bleibt unklar, wie die Trainingsinterventionen konkret inhaltlich strukturiert sein sollten, um neben der Alltagsfunktionalität, die Lebenszufriedenheit und das psychosoziale Wohlbefinden zu verbessern. Über Intensität, Dauer und Frequenz des Trainings wird ebenfalls nur wenig berichtet. Bis heute gibt es keine evidenzbasierten Richtlinien zur Förderung der körperlichen Aktivität bei multimorbiden BewohnerInnen in der Altenpflege (De Souto Barreto et al., 2016, Nelson et al., 2007). Statistisch sind etwa die Hälfte der BewohnerInnen in der stationären Altenpflege auf einen Rollstuhl angewiesen (Shields, 2004). Dennoch zielen die meisten Interventionen auf die Förderung von noch gehfähigen BewohnerInnen ab (Schaeffer et al.,2016). Ein Bericht von der International Association of Gerontology and Geriatrics - Global Aging Research Network (IAGG-GARN) und der IAGG European Region Clinical Section (De Souto Barreto et al., 2016) gibt Empfehlungen für körperliche Aktivität bei BewohnerInnen der stationären Altenpflege und schlägt ein multikomponentes Übungsprogramm mit Inhalten zur Kräftigung der Muskulatur und Steigerung der Ausdauer vor, welches mit Gleichgewichts- und Beweglichkeitsübungen ergänzt werden kann. Die Trainingsintensität sollte demnach moderat sein. Moderate Intensität wird erreicht, indem die Kraftübungen mit 13–15 Wiederholungen in ein bis zwei Sätzen durchgeführt werden. Bei Ausdauerübungen sollten Herz- und Atemfrequenz merkbar erhöht sein, ohne dabei Atemlosigkeit oder übermäßige Erschöpfung hervorzurufen. Zudem sollte das Training zweimal wöchentlich für 45 Minuten stattfinden. Studien, die diese Empfehlung wissenschaftlich belegen sowie die Durchführbarkeit und die Effektivität eines solchen Trainingsprogramms für hochaltrige, nicht-gehfähige BewohnerInnen in der stationären Altenpflege adressieren, fehlen bislang.

Ziel der Machbarkeitsstudie war es daher zu untersuchen, ob und wie eine sitzgymnastische Trainingsintervention für nicht-gehfähige BewohnerInnen in der stationären Altenpflege durchführbar ist, und ob dadurch eine Verbesserung der Alltagsfunktionalität sowie eine Steigerung der Lebenszufriedenheit und des Wohlbefindens erreicht werden kann. Es wird angenommen, dass ein Training noch bestehender physischer Funktionen wie Handkraft und Gleichgewicht die Alltagsfunktionalität erhalten oder verbessern und somit zu einer gesteigerten Lebenszufriedenheit beitragen kann.

Methode

Studiendesign

Die Machbarkeitsstudie untersuchte im Prä-Post-Design die Wirksamkeit eines 16-wöchigen, sitzgymnastischen, multikomponenten Trainingsprogramms (Abb. 1).

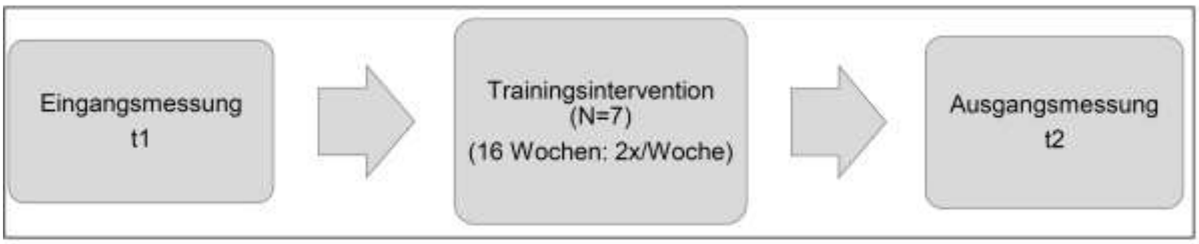

Abb. 1. Flow Diagramm der Machbarkeitsstudie.

Probanden

Untersucht wurden N=7 multimorbide, nicht- gehfähige BewohnerInnen mit einem Durchschnittsalter von 85 Jahren (SD = 5.2) in einer stationären Altenpflegeeinrichtung. Einschlusskriterien waren der freiwillige Wunsch zur Teilnahme, die Fähigkeit, aufrecht sitzen zu können sowie die Fähigkeit, einfache Aufgaben verstehen zu können.

Intervention

Ein 16-wöchiges, sitzgymnastisches, multikomponenten Trainingsprogramm mit progressiven Übungen für Kraft, Ausdauer, Beweglichkeit und Koordination wurde zweimal pro Woche für 60 Minuten durchgeführt. Zum Einsatz kamen motivierende Materialien wie bunte Tücher und Bälle, Spielformen mit Alltagsbezug sowie Übungen mit leichten Gewichten, Stäben und Handtüchern. Die Auswahl setzte sich aus Übungen zusammen, die in anderen Seniorensportprogrammen erfolgreich evaluiert und umgesetzt wurden (Schaeffer et al., 2016). Zur Ressourcensteigerung wurden die Übungen für ein ausschließlich sitzgymnastisches Programm modifiziert und unter Zuhilfenahme der Borg Skala (Borg, 1982) hinsichtlich Intensität und Umfang stetig progressiv angepasst. Während des Trainings wurde ein Borg Skalenwert im Bereich 12-14 für moderate/etwas anstrengende Intensität angestrebt. Für eine Intensitätssteigerung wurde zunächst die Anzahl der Wiederholungen bzw. die Dauer einer Übung erhöht. Im progressiven Verlauf wurden zudem die Anzahl der Trainingssätze von zwei auf drei erhöht und Gewichte von 1-2 kg hinzugenommen.

Messinstrumente

Die Bestimmung der Alltagsfunktionalität erfolgte über die Handkraft mit einem hydraulischen Handdynamometer (JAMAR, hydraulic hand dynamometer) und das funktionelle Gleichgewicht im Sitzen mit dem Functional Reach Test (Duncan et al., 1990). Zudem wurde das physische und psychische, gesundheitsbezogene Wohlbefinden mit dem SF-12 (Ware et al., 1998) und die Lebenszufriedenheit mit der Satisfaction with Life Scale (Glaesmer et al., 2011) überprüft.

Statistik

Zur statistischen Analyse wurde der Wilcoxon-Test für verbundene Stichproben durchgeführt ($p < 0,025$).

Ergebnisse

Die Auswertung zeigte eine höhere Handkraft von t1 (*Mdn = 11 kg*) zu t2 (*Mdn = 18 kg; Z = 2.38, p = .017*). Zudem verbesserten sich die Bewohnerinnen functional reach test von t1 (*Mdn = 98 cm*) zu t2 (*Mdn = 119 cm; Z = 2.36, p = .018;* Abbildung 2).

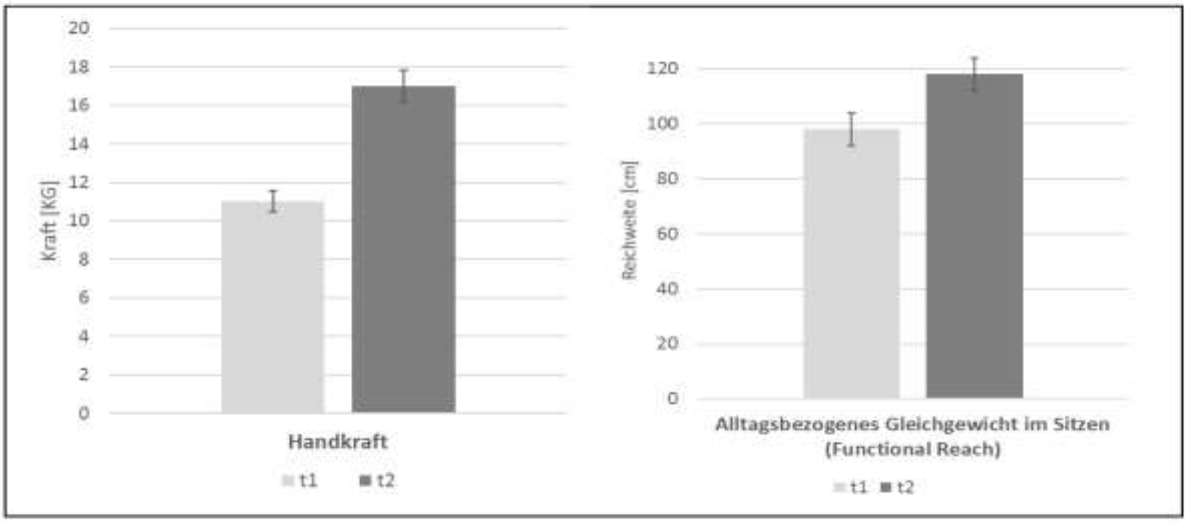

Abb. 2. Handkraft und Gleichgewicht im Vergleich Eingangsmessung (t1) zu Ausgangsmessung (t2)

Abbildung 3 zeigt die positive Entwicklung des physischen Wohlbefindens von t1 zu t2 (*Z = 1.86, p = .063*) sowie ein unverändertes psychisches Wohlbefinden von t1 zu t2 (*Z = 0, p = 1*).

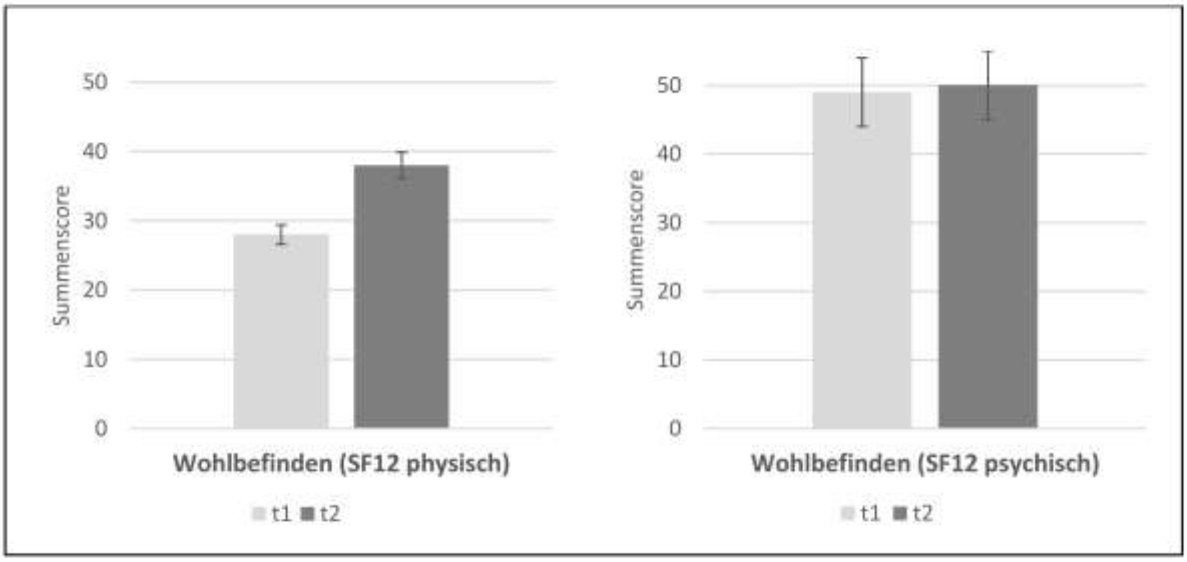

Abb. 3. Gesundheitsbezogene physische (links) und psychische (rechts) Wohlbefinden. Ergebnisse von t1 Eingangsmessung (hellgrau) zu t2 Ausgangsmessung (dunkelgrau).

Die Lebenszufriedenheit, dargestellt in Abbildung 4, ist mit einer leichten Steigerung von t1 (*Mdn = 22*) zu t2 (*Mdn = 23; Z = 0, p = 1*) nahezu stabil geblieben.

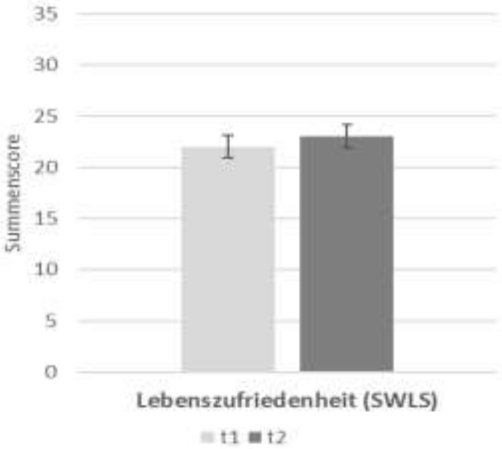

Abb. 4. Lebenszufriedenheit mit der Satisfaction with Life Scale (SWLS). Ergebnisse von t1 Eingangsmessung (hellgrau) zu t2 Ausgangsmessung (dunkelgrau).

Das Training wurde von allen BewohnerInnen als positiv für den Erhalt von Alltagsfunktionen bewertet. Zudem gab es positive Rückmeldungen zu Funktionsverbesserungen im Alltag vom Betreuungspersonal.

Diskussion

Ziel der Machbarkeitsstudie war es, die Durchführbarkeit und die Effektivität eines multikomponenten Trainingsprogramms zur Verbesserung der Alltagsfunktionalität von nicht-gehfähigen BewohnerInnen in der stationären Altenpflege zu untersuchen. Zudem sollten die Ergebnisse Aufschluss darüber geben, ob ein Training der physischen Funktionen die Alltagsfunktionalität steigert und damit zu mehr Lebensqualität und Wohlbefinden beitragen kann.

Die Ergebnisse zeigen, dass die InterventionsteilnehmerInnen ihre Handkraft erhöhten und das Gleichgewicht im Sitzen (Sit & Reach) im Verlauf von 16 Wochen steigern konnten. Ohne reguläres Training wäre in diesem Setting mit einer stetigen Abnahme von Handkraft und Gleichgewicht zu rechnen gewesen (Masciocci et al., 2019). Das physische Wohlbefinden hat sich von t1 zu t2 ebenfalls verbessert während das psychische Wohlbefinden und die Lebenszufriedenheit stabil blieben. Obwohl hier keine Verbesserung festgestellt wurde, ist selbst der Erhalt bei dieser multimorbiden Zielgruppe als Erfolg zu werten, da auch die psychosozialen Funktionen in der Altenpflege durch eine stetige Abnahme gekennzeichnet sind (Scheid-Nave et al., 2010). Die Stabilisierung der gesundheitlichen Situation und die Verhinderung einer Abwärtsentwicklung stehen hierbei im Vordergrund (Schaeffer et al., 2009). Um motorische und psychosoziale Ressourcen von nicht-gehfähigen BewohnerInnen zu stärken, erwies sich das multikomponente Programm mit moderater Intensität als geeignet und gut durchführbar. Durch eine progressive Steigerung der Intensität wurde ein trainingswirksamer Reiz gesetzt und ein erwarteter Zuwachs der Komponenten Kraft und Gleichgewicht erzielt. Diese Steigerung steht in direktem Zusammenhang mit einer verbesserten physischen Funktionsfähigkeit bezogen auf die ADL (Covinsky et al., 2003) und wirkt sich somit positiv auf die Lebenszufriedenheit und das Wohlbefinden aus (Kehyayan et al., 2016).

Weitere Untersuchungen sind erforderlich, um konkrete Empfehlungen zu Intensität und Trainingsinhalten geben zu können, die dazu beitragen, dass bei zukünftigen Trainingsinterventionen auch die Bedarfe und Ressourcen der nicht-gehfähigen BewohnerInnen berücksichtigt werden. Eine Fallzahlberechnung (Effektstärke f: 0,3; α err prob: 0,05; Power: 0,95) hat ergeben, dass randomisiert-kontrollierte Studien eine Stichprobengröße von N=32 benötigen um die Ergebnisse zu bestätigen. Zusammenfassend konnte die Durchführbarkeit des multikomponenten Trainingsprogramms belegt werden. Zudem steigerte die Intervention die Alltagsfunktionalität und stabilisierte die Lebenszufriedenheit und das Wohlbefinden von nicht-gehfähigen BewohnerInnen in der stationären Pflegeeinrichtung.

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Anhang F: Publikation V

Cordes, T., Zwingmann, K., Rudisch, J., Voelcker-Rehage, C. & Wollesen, B. (2021). Multicomponent exercise to improve motor functions, cognition and well-being for nursing home residents who are unable to walk – A randomized controlled trial. *Experimental Gerontology, 153*, 111484. https://doi.org/10.1016/j.exger.2021.111484

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Multicomponent exercise to improve motor functions, cognition and well-being for nursing home residents who are unable to walk – A randomized controlled trial

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ABSTRACT

Background: Older nursing home residents are often characterized by multimorbidity and dependency in activities of daily living. Most exercise studies in this setting aim at residents who are still able to walk despite the huge group of residents that is unable to walk. Thus, little is known about the effectiveness to improve cognitive and motor functions as well as well-being within this target group, e.g., by use of chair-based exercises. The aim of this study was to determine the effects of a 16-week multicomponent chair-based exercise intervention on motor functions, cognition and well-being for nursing home residents who are unable to walk.
Methods: A two-arm single-blinded multicenter randomized controlled trial integrated $N = 52$ nursing home residents with a mean age of 81 ± 11 years (63% female), randomly assigned to a training ($n = 26$, 16 weeks; twice a week; 60 min) or a wait-list control group ($n = 26$). The intervention followed the F.I.T.T. principles (frequency, intensity, time and type) and was continuously adapted to residents' performance level. The outcomes motor function (hand grip strength, sitting balance, manual dexterity), cognitive performance (cognitive status, working memory) and psychosocial resources (physical and mental well-being (SF12), satisfaction with life (SWLS), depressive symptoms (CES-D)) were assessed at baseline (pre-test) and after 16-weeks (post-treatment). Statistics were performed using ANOVA for repeated measures.
Results: The results of the ANOVA showed significant improvements of the intervention group for hand grip strength (Pre: $M = 12.67$, $SD = 5.28$; Post: $M = 13.86$, $SD = 4.79$; Group × Time: $F(1, 17) = 10.816$, $p = .002$, $\eta_p^2 = 0.241$), manual dexterity (Pre: $M = 4.50$, $SD = 5.17$; Post: $M = 5.30$, $SD = 4.25$; Group × Time: $F(1, 7) = 9.193$, $p = .008$, $\eta_p^2 = 0.365$), cognition (Pre: $M = 10.31$, $SD = 6.87$; Post: $M = 11.06$, $SD = 7.50$; Group × Time: $F(1, 15) = 12.687$, $p = .001$, $\eta_p^2 = 0.284$), and depression (Pre: $M = 5.19$, $SD = 5.12$; Post: $M = 4.38$, $SD = 4.62$; Group × Time: $F(1, 14) = 5.135$, $p = .031$, $\eta_p^2 = 0.150$) while the values of the control group decreased.
Conclusion: The multicomponent chair-based intervention over 16 weeks was able to improve motor functions and cognition in nursing home residents who are unable to walk. Other psychological factors remained stable within the intervention group, which can be interpreted as a good result for this target group. All of the investigated parameters showed a significant decrease in the control group. The intervention seemed to cause physiological adaptations even in very old age. Study results encourage to further differentiate the heterogeneous group of nursing home residents concerning mobility aspects and to include chair-based interventions as feasible program to prevent further decline of functional performance and maintain independence in activities of daily living for a better physical and mental well-being.

Abbreviations: ADL, activities of daily living; CBE, chair-based exercise; DT, dual-task; IG, intervention group; CG, wait-list control group.

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1. Introduction

Roughly 25–50% of the population older than 85 years is estimated to be frail (Clegg et al., 2013). In Germany 59% deal with strong limitations on activities of daily living (ADL), 85% require help with personal care like brushing teeth, grooming and washing hands, and 70% have mobility restrictions like the inability to walk or transfer to bed or a chair (Schaeffer and Büscher, 2009). By the end of 2019, 4.1 million people in Germany were in need of care with 0.82 million living in nursing homes (Statistisches Bundesamt [Destatis], 2019). Similar numbers are reported for other western countries (OECD, 2019). This highlights the particular demand for health promotion and interventions to prevent and delay disability in the heterogeneous group of elderly persons. Furthermore, nursing home residents are often characterized by multimorbidity, a high level of dependency, and low levels of mobility with a high risk of losing the ability to walk (Ferrucci et al., 2004; Valenzuela, 2012). The loss of strength has important functional consequences with regard to the residents' ability to walk (Williams et al., 2005; Cadore et al., 2019) and to perform ADL (Valenzuela, 2012). Moreover, the loss of motor functions in relation to ADL is associated with a higher degree of dependency, decline of cognitive abilities and quality of life (Kehyayan et al., 2015). Therefore, resources of nursing home residents related to motor functions (Kazoglu and Yuruk, 2020; Ferrucci et al., 2004) cognition (Forbes et al., 2013), and improvements in psychosocial well-being (Conradsson et al., 2015) need to be maintained by targeted exercise programs.

Due to physical and physiological limitations such as muscle weakness and impaired balance (Karmarkar et al., 2011) most residents in nursing homes use mobility devices such as wheelchairs as their primary means of mobility (Karmarkar et al., 2011; Shields, 2004). Exercise interventions to improve motor functions, however, typically comprise exercises that require the ability to stand or to walk, also in clinical practice (Bischoff et al., 2020; Gillespie et al., 2012; Jahanpeyma et al., 2021) and therefore do not incorporate the particularly vulnerable group of residents not able to walk. This emphasizes the importance of a differentiation within the heterogeneous group of nursing home residents, e.g. in terms of mobility. Very frail residents with weak balance and mobility who depend on a wheelchair are unable to participate in programs with walking or standing exercises. Hence, there is a conceptual gap in the field of prevention in nursing home care that needs to be closed (Anthony et al., 2013). This leads to the assumption that the health situation of nursing home residents is not adequately addressed in intervention programs: wheelchair use seems to be a barrier to participate in physical activity interventions. Therefore, the lack of adequate exercise interventions for nursing home residents who are unable to walk might lead to further disability and mortality (Hirvensalo et al., 2000) as well as social isolation (Ridda et al., 2010). The latter limits the opportunities for participation and ultimately leads to a higher vulnerability and reduced well-being (Schaeffer and Büscher, 2009).

Nevertheless, for ambulatory nursing home residents exercise interventions with resistance (Crocker et al., 2013; Valenzuela, 2012; Weening-Dijksterhuis et al., 2011), mobility and balance training (Crocker et al., 2013) have been shown to positively affect independence and the ability to perform ADL (Valenzuela, 2012). Moreover, it is well investigated that frail individuals aged 80 and older are still able to increase their muscle function through resistance training (Johnen and Schott, 2018; Kryger and Andersen, 2007; Weening-Dijksterhuis et al., 2011). Even nursing home residents in long-term care with reduced motor functions can develop a higher independence (Arrieta et al., 2018) and increase their psychosocial resources through exercise (Lok et al., 2017; Yümin et al., 2011). Additionally, it is clearly stated that without exercise, physical performance in nursing home residents decreases over time which aggravates the ability to perform ADL and reduces well-being (Masciocchi et al., 2019; Valenzuela, 2012). Furthermore, it has been shown that exercise interventions can lead to a better cognitive function to perform ADL (e.g., working memory, executive functions, attention) in nursing home residents (Forbes et al., 2013; Li et al., 2019) and improve their psychophysiological well-being. In this vein, a meta-analysis found that exercise increases fitness, motor functions as well as cognitive functions and betters the mood in people with dementia (Karssemeijer et al., 2017).

Chair based exercises (CBE) are used as an alternative form of exercise for multimorbid persons and may be feasible and accessible for older people with physical limitations who may not be able to take part in other exercise programs (Anthony et al., 2013; Robinson et al., 2016). CBE have been shown to have a beneficial effect on maintaining or promoting independence and mobility in residential care homes (Cancela Carral et al., 2017). A recently published review summarized the current evidence on CBE interventions for nursing home residents and found out that multicomponent exercises appear to improve different domains of motor and cognitive function (Cordes et al., 2020). However, there is a lack of evidence for CBE due to low quality with small sample sizes and poor methodological techniques (Cordes et al., 2020). Accordingly, the existing studies only show small effects that may not apply to all residents (Crocker et al., 2013) and studies with separation of residents who are able and those who are unable to walk are rare (Cordes et al., 2020). Hence, specific guidance for clinical practice is missing for nursing home residents who are unable to walk (Anthony et al., 2013; Cordes et al., 2020). Also, there is a lack of consensus on the fundamental principles of CBE (Robinson et al., 2016) and there is limited evidence on how previous general recommendations are transferable to a population of nursing home residents who are unable to walk. Although, these exercise effects were mostly demonstrated for nursing home residents who are able to walk, we hypothesized that similar effects might also be achieved through targeted CBE with residents who are unable to walk.

In addition, the so far applied CBE differ largely with respect to the type of exercise. Thus, it is still unclear which type and content of exercise yields the most beneficial results. Multicomponent exercise interventions (e.g., a combination of strength, endurance, balance, coordination and task-specific training on ADL) combined with cognitive exercises (Jansen et al., 2015; Schoene et al., 2014; Wollesen et al., 2017; Wollesen and Voelcker-Rehage, 2014) have shown promising results and might be beneficial against programs that use only one physical conditioning-component (Cadore et al., 2013). However, most multicomponent exercise studies investigated healthy older adults. Less is known about the effectiveness of multicomponent exercise programs integrating endurance, strength, coordination task-specific training on ADL, and motor-cognitive dual-task exercises for health promotion in nursing home residents. Nevertheless, first studies investigating multicomponent exercise including stepping and walking exercises indicate benefits regarding motor functions (Arrieta et al., 2018; Arrieta et al., 2019). In addition, motor-cognitive dual-task exercises are beneficial for improving physical and cognitive performance in older adults (Wollesen et al., 2020; Wollesen and Voelcker-Rehage, 2014) and for patients with dementia (Schwenk et al., 2010). Therefore, they should be integrated into the multicomponent programs as nursing home residents are vulnerable for cognitive decline.

Additionally, to the type of exercise, the training modalities should be specified. A recent report from the International Association of Gerontology and Geriatrics - Global Aging Research Network (IAGG-GARN) and the IAGG European Region Clinical Section provides exercise and intensity recommendations for multicomponent training interventions for people in need of care (de Souto Barreto et al., 2016). The report emphasizes that moderate training intensities that are continuously adapted to the residents' abilities are most beneficial. Strength training should thus include 13–15 repetitions in one or two sets. For endurance training, the heart and respiratory rate should be noticeably increased, however, without causing breathlessness or excessive exhaustion. In addition, the report recommends a training frequency and duration of twice a week for 45 min (de Souto Barreto et al., 2016). In order to achieve an effective training stimulus, training should be continuously adapted to the capacity of the residents and organized as a progressive challenge (Herold et al., 2019; Jahanpeyma et al., 2021). This can be ensured by adjusting the duration, frequency, and/or intensity of the exercises in accordance with the F.I.T.T. principles (frequency, intensity, time, and type) (Garber et al., 2011). Yet, in most of the studies for nursing home residents, precise information for training modalities, e.g. duration, frequency, and how to adjust a suitable intensity to provide a sufficient stimulus for muscle adaptation is missing (Cordes et al., 2020).

Hence, the aim of the study was to examine the effectiveness of a multicomponent CBE intervention for nursing home residents who are unable to walk. The investigated key domains were motor function, cognition and psychosocial well-being. This leads to the following main research question: Can a tailored multicomponent CBE intervention following the IAGG-GARN exercise recommendations and F.I.T.T. principles improve or sustain resources in the motor (such as hand grip strength, dynamic sitting balance, clinical manual dexterity and independence in ADL), cognitive (such as cognitive status and working memory) and psychosocial (such as physical and mental well-being, satisfaction with life, depressive symptoms) domains of nursing home residents who are unable to walk? According to the above-mentioned current literature, we hypothesized that such a multicomponent exercise intervention is able to improve or sustain motor function resources (*hypothesis 1*), cognitive resources (*hypothesis 2*) and psychosocial resources (*hypothesis 3*) of nursing home residents who are unable to walk.

2. Methods

The CONSORT statement (Moher et al., 2010) was used as a guideline for the reporting of this trial.

2.1. Trial design

This study was a two-arm single-blinded randomized controlled trial of an individually tailored multicomponent intervention for nursing home residents who are unable to walk. The trial is part of the PROCARE project (Prevention and occupational health in long-term care) and a study protocol (Cordes et al., 2019) is publicly available and registered at DRKS.de with registration number DRKS00014957.

2.2. Participants and recruitment

Assessment of eligibility and recruitment of participants with respect to inclusion and exclusion criteria was primarily based on nursing documentation and staff consultation. Care management and lead investigators met to discuss and create a list with ($N = 82$) suitable nursing home residents (ability to participate in group activities, sit unassisted on a chair or in a wheelchair, understand and execute simple instructions, and being unable to walk) out of 319 residents in total from four nursing homes prior to the study enrollment. Nursing staff informed all suitable residents or their legal guardians about the study goals and asked for voluntary participation. A number of $n = 30$ residents did not meet the inclusion criteria. In total $N = 52$ residents with a mean age of

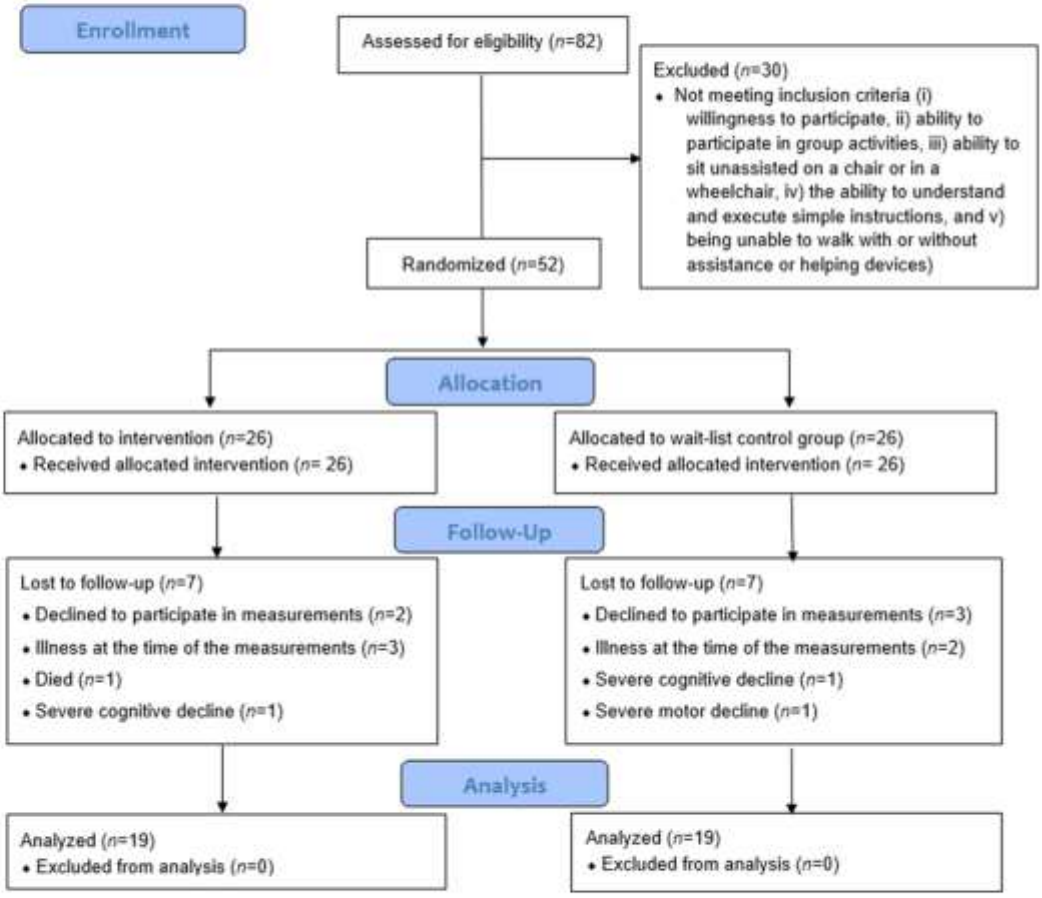

Fig. 1. Participant flowchart.

81 years (SD ± 11, age range 70 to 92 years, 63% female) from four different nursing homes in Bremen and Chemnitz, Germany were included in the trial (cf. Fig. 1).

Criteria of suitability and study inclusion were i) willingness to participate, ii) ability to participate in group activities (based on nursing staff judgement about the residents psycho-social and mental stability), iii) ability to sit unassisted on a chair or in a wheelchair, iv) the ability to understand and execute simple instructions (Cordes et al., 2019), and additionally v) being unable to walk with or without helping devices. No other inclusion or exclusion criteria were applied.

Written informed consent was obtained from all participants or their legal guardians prior to the study enrollment according to the Declaration of Helsinki. The ethics committee of the Hamburg Chamber of Physicians, Germany, has approved the previously published study protocol regarding the group of nursing home residents who are able to walk (Cordes et al., 2019) (PV5762). Subject characteristics of the participants who are not able to walk are presented in Table 1. There were no significant differences in any of the baseline characteristics between $N = 52$ nursing home residents of the intervention group (IG) and the wait-list control group (CG). A participant flowchart is presented in Fig. 1.

2.3. Randomization and assignment to the intervention

To avoid selection bias, a stratified randomization was conducted after the baseline assessment to divide the participants into either an intervention group or a wait-list control group. The assessment of the outcomes took place in all subjects upon entry to the study (T1) by a blinded assessor and was repeated at 16 weeks (T2) after randomization.

The random allocation was stratified and executed by lot by the director of the study who received the pseudonymized codes of the participants and their baseline characteristics and was not involved in neither the assessment nor the intervention procedures. Stratification was based on comparable sex, age, and cognitive status (according to the Montreal Cognitive Assessment MoCA-Score (Nasreddine et al., 2005)) to avoid differences within the two groups. After the director of the study assigned the participants to the IG or CG, the pseudonymized participant codes were sent to the study investigators responsible for data management. The baseline characteristics can be found in Table 1.

2.4. Blinding

The exercise scientist or physiotherapist, who conducted the intervention, only received names of the participants in the IG and after 16 weeks names of the CG without being aware of the control group design.

Table 1
Baseline characteristic of participants (mean ± SD).

	IG (n = 26)	CG (n = 26)	F-statistics p		
			F (1,51)	p	η_p^2
Females, N (%)	17 (65%)	16 (62%)	0.080	.779	0.002
Age (years, mean ± SD)	82.69 ± 10.26	80.12 ± 11.37	0.736	.395	0.015
Body mass (kg, mean ± SD)	66.60 ± 16.21	72.47 ± 19.42	1.396	.243	0.027
Body-mass-index (kg/m², mean ± SD)	24.93 ± 6.22	27.46 ± 5.88	2.257	.139	0.043
Barthel Index (score, mean ± SD)	42.00 ± 19.04	37.50 ± 22.99	0.577	.451	0.012
MoCA (score, mean ± SD)	10.31 ± 6.87	12.50 ± 6.18	0.957	.335	0.029
CES-D (score, mean ± SD)	5.19 ± 5.12	6.00 ± 3.67	1.166	.289	0.039

Note. IG = intervention group; CG = control group; MoCA = Montreal Cognitive Assessment (Nasreddine et al., 2005); CES-D = Center for Epidemiologic Studies Depression Scale (Radloff, 1977).

Assessment and data collection were done by blinded assessors in a strictly pseudonymized form to guarantee a blinded data analysis. These blinded assessors were research assistants who conducted the assessments without being aware of which group the residents belonged to. To stay blinded the assessors were not involved in the organization of the intervention or communication to the staff. To avoid performance bias, the measurements and the intervention followed a standardized protocol. All participant information and data were stored securely and identified by a coded ID number only to maintain participants' confidentiality.

2.5. Sample size estimate/power calculations

The required sample size was calculated with G*Power (version 3.1.9.2, Heinrich Heine University of Duesseldorf) (Faul et al., 2009). The sample size calculation was approximated with a 2 × 2-factorial analysis of variance (ANOVA) for repeated measures (within-between interaction, medium effect size ($f = 0.3$), power of 0.80 [$1 - \beta$], 2-sided α-error (95% CI), 2 groups, 2 measurements) based on all outcomes. A medium effect ($f = 0.3$) was assumed, which is common in studies in the geriatric setting. 32 participants were required in order to detect a clinically meaningful change of ≥1.0 point with a SD of 0.99 points. To account for potential dropouts before study completion, we inflated the sample size by 30% (20% losses during follow-up; 10% mortality), resulting in a total sample size of 42 individuals (21 participants allocated to each group).

2.6. Multicomponent chair-based exercise program

The multicomponent CBE program follows IAGG guidelines. It was also developed based on recommendations for nursing home residents (de Souto Barreto et al., 2016), results from a review regarding CBE (Cordes et al., 2020), and previously published exercises that have been proven to be advantageous for physical, and motor-cognitive function in older people in the community (Baker et al., 2007; Wollesen and Voelcker-Rehage, 2014) and in need of care (Arrieta et al., 2018; Valenzuela, 2012). The exercise program consisted of 32 sessions and was conducted in a period of 16 weeks. One training session lasted 60 min and training took place twice a week. A training group consisted of an average of 6–7 participants using their own wheelchairs or transferred to a chair with armrests. The training took place in a room inside the nursing home. For each training session, the residents were brought into the training room by the nursing staff and picked up again afterwards. During the exercise sessions there was no further help from the staff.

In order to create the exercises motivational and target-group-specific music as well as playful and motivational equipment (e.g., balls, scarfs, and parachutes) were used. To ensure a controllable structure, training sessions were divided into five parts:

1. 5–10 minute warm-up and mobilization (e.g., slow aerobic and range of motion exercises for hip, shoulders, knees, wrists and ankles, chest expansion, arm circles, hip rotation, rhythmic movements with music, scarfs, parachute and other motivational equipment).
2. 15 minute coordination and motor-cognitive games with group interaction under single and dual-task conditions (e.g., counting backwards and react to signs while handling a ball).
3. 10 minute task-specific exercises for ADL skills with everyday objects (e.g., towel, newspaper, cups).
4. 10–15 minute strength and aerobic exercises (e.g., progressive trunk, upper- and lower body exercises with additional weights of 1–2 kg, balls, and gymnastic sticks).
5. 5–10 minute calm down (e.g., relaxing and stretching exercises).

The moderate intensity of exercises was continuously adapted to the residents' capacity and was organized as a progressive challenge. This was ensured by adjusting the duration, frequency, range of motion and/or intensity of the exercises in accordance to the F.I.T.T principles (Garber et al., 2011). Regarding strength or aerobic exercises, progression was ensured by adjusting the number of repetitions (from 5 to 10 to 15 to 20), the number of sets (1, 2 or 3), and/or by usage of additional weights (1 or 2 kg). For coordination exercises, the difficulty level was raised by introducing additional items (e.g., handling more than one ball at once) and/or adding a secondary cognitive task, to train under dual-task conditions such as counting backwards during the exercise. Based on the trainer's rating and residents' perceived exhaustion, regular short breaks were taken during the training sessions. The participants were able to take individual breaks whenever they needed one.

No other concomitant group exercise interventions were permitted besides usual care. CG participants were asked to continue their regular everyday activities. An example of a training session with progression of exercises over the course of the intervention is displayed in Table 2. The training was administered by a certified exercise scientist or physiotherapist in a room located in the nursing home facility. During each session of the interventions, adverse events (e.g. falls, illnesses or dizziness) were monitored but no such event occurred. A feasibility study (Bischoff et al., 2020) was conducted prior to the trial to evaluate the multicomponent training intervention. As a result, adaptions for the target group secured the feasibility in a nursing home and for the participants who are unable to walk.

2.7. Outcome measures

The assessment focused on three key domains: motor function, cognitive performance, and psychosocial well-being. Apart from the following outcomes, demographic and baseline characteristics (age, height, weight, body mass index, and sex) were assessed (Table 1). For every of the following outcomes missing values due to reasons of practical measurement difficulties of the setting and the target group occurred (e.g. participants were absent sick or employed with other appointments during measurements). The number of analyzed participant data for both groups is clearly stated in Tables 3 to 5.

The following outcomes were measured to assess the effectiveness of the intervention:

Motor function outcomes

Hand grip strength was measured with a hydraulic hand dynamometer (JAMAR, hydraulic hand dynamometer, model 5030J1, J. A. Preston Corporation, Clifton, NJ). Measurements were taken in a seated position with the forearm resting on the arm of a chair or on the table and the dynamometer placed in the participants' hand, hanging in a free position. This position was recommended by the American Society of Hand Therapists (Fess, 1983) and described in the standard operating procedure for grip strength testing by the Sheffield Clinical Research Facility (2012). Three trials with the right hand followed by three trials with the left hand were executed. The time between trials was about 15 s, which was the time needed to read and record each score. Performance in kilogram of the three trials was averaged for both hands separately.

The Barthel Index (Mahoney and Barthel, 1965) was used to systematically record the independence of participants when performing basic ADL via ten items. Feeding, personal toileting, bathing, dressing and undressing, getting on and off a toilet, controlling bladder, controlling bowel, moving from wheelchair to bed and returning, walking on level surface (or propelling a wheelchair if unable to walk) and ascending and descending stairs were rated by

Table 2
Exercise examples of training sessions with progression of exercises over the course of the intervention.

Training components	Level 1 Week 1–4	Level 2 Week 5–8	Level 3 Week 9–12	Level 4 Week 10–16
Mobilization and warm-up	Moderate mobility and range of motion exercises for the wrists, hip, shoulders, knees, and ankles	Moderate mobility and range of motion exercises for the wrists, hip, shoulders, knees, and ankles	Moderate mobility and range of motion exercises for the wrists, hip, shoulders, knees, and ankles	Moderate mobility and range of motion exercises for the wrists, hip, shoulders, knees, and ankles
Coordination and motor-cognitive exercises	Balls move clockwise and/or counterclockwise (variation left-, right-, both hands, commands w. change of directions)	+ dual-task: verbal fluency task naming of words with the same starting letter	+ dual-task: counting backwards by 1's from 100 during exercise	+ dual-task: counting backwards by 3's from 100 during exercise
	Participants throw a ball towards each other	+ dual-task: count throws, call each other's names	Throw balloons, play crisscross without touching the ground counting touches of the ground	+ dual-task: count touches and count touches of the ground, call each other's names
	Cognitive-motor tales (incorporated movement into stories e.g., a visit in the garden, beach, or market)	Memory games (e.g. "I packed my suitcase with…" or "When I wake up the first thing I do is…") combined with coordination exercises based on ADL matching the answers	Cognitive-motor tales (incorporated movement into stories e.g., a visit in the garden, beach, or market)	Memory games (e.g. "I packed my suitcase with…" or "When I wake up the first thing I do is…") combined with coordination exercises based on ADL matching the answers
ADL	Exercises with everyday objects (e.g., towel, newspaper, cups)	Exercises with everyday objects (e.g., towel, newspaper, cups)	Exercises with everyday objects (e.g., towel, newspaper, cups)	Exercises with everyday objects (e.g., towel, newspaper, cups)
	Throwing scarfs in the air and catching with the same or opposite hand	Throwing scarfs in the air and catching with the same or opposite hand	Throwing scarfs in the air and catching with the same or opposite hand	Throwing scarfs in the air and catching with the same or opposite hand
Strength and aerobic exercises	Bending and stretching knees, 20 repetitions	Bending and stretching knees, 2 × 20 repetitions	Bending and stretching knees, 3 × 15 repetitions	Bending and stretching knees, 3 × 15 repetitions + 1–2 kg weights
	Rowing with stick, 15 repetitions	Rowing with stick, 2 × 15 repetitions	Rowing with stick, 3 × 15 repetitions	Rowing with stick, 4 × 15 repetitions
	Rotation of upper body, 10 repetitions	Rotation of upper body, 2 × 15 repetitions	Rotation of upper body, 3 × 15 repetitions	Rotation of upper body, 3 × 15 repetitions with 1–2 kg weights
	Strength exercises with the towel (e.g., compress between knees) 10 × 3 s.	Strength exercises with the towel, 10 × 5 s.	Strength exercises with the towel, 15 × 5 s.	Strength exercises with the towel, 20 × 5 s.
	Biceps Curls and making a fist, 1 × 15 repetitions	Biceps Curls and making a fist, 2 × 15 repetitions	Biceps Curls 1–2 kg weights, 2 × 15 repetitions	Biceps Curls 1–2 kg weights, 3 × 15 repetitions
Calm down	Stretching exercises and progressive muscle relaxation	Stretching exercises and progressive muscle relaxation	Stretching exercises and progressive muscle relaxation	Stretching exercises and progressive muscle relaxation

Table 3
Descriptive values and F-statistics for the 2 Time (Pre, Post) × 2 Groups (IG, CG) mixed measures ANOVAs for the motor function outcomes ADL (Barthel Index), clinical manual dexterity (Purdue Pegboard; for both hands), dynamic sitting balance (modified functional reach test) and hand grip strength (dynamometer; mean value of left and right).

	n	Pre			Post			F-statistics				
		M (±*SD*)	*CI*		*M* (±*SD*)	*CI*			*df*	*F*	*p*	η_p^2
ADL (Barthel Index)												
			Lower	Upper		Lower	Upper	Time	1	1.785	.189	0.040
IG	22	40.91 (±19.92)	31.55	50.27	43.41 (±21.46)	34.24	52.58	Group	1	0.805	.375	0.018
CG	23	39.57 (±23.40)	30.41	48.72	33.48 (±21.18)	24.51	42.44	Time × Group	1	10.229	.003*	0.192
Clinical manual dexterity (Purdue Pegboard)												
			Lower	Upper		Lower	Upper	Time	1	2.931	.106	0.155
IG	10	4.50 (±5.17)	1.42	7.58	5.30 (±4.25)	2.79	7.81	Group	1	0.597	.451	0.036
CG	8	4.88 (±3.72)	1.43	8.32	2.00 (±2.98)	−0.81	4.81	Time × Group	1	9.193	.008*	0.365
Dynamic sitting balance (Modified Functional Reach Test)												
			Lower	Upper		Lower	Upper	Time	1	1.105	.302	0.036
IG	17	20.82 (±9.89)	16.00	25.65	25.71 (±10.81)	20.32	31.09	Group	1	1.796	.190	0.056
CG	15	22.73 (±9.58)	17.59	27.87	14.80 (±10.94)	9.07	20.53	Time × Group	1	19.489	<.001**	0.394
Hand grip strength (Dynamometer)												
			Lower	Upper		Lower	Upper	Time	1	0.354	.565	0.010
IG	18	12.67 (±5.28)	9.85	15.49	13.86 (±4.79)	11.27	16.45	Group	1	0.106	.746	0.003
CG	18	13.53 (±6.44)	10.71	16.35	11.80 (±5.95)	9.22	14.39	Time × Group	1	10.816	.002*	0.241

Note. IG = intervention group; CG = control group.
* $p < .05$.
** $p < .01$.

Table 4
Descriptive values and F-statistics for the 2 Time (Pre, Post) × 2 Groups (IG, CG) mixed measures ANOVAs for the cognitive outcomes counting backwards (steps of one) and cognitive status (MoCA).

	n	Pre			Post			F-statistics				
		M (±*SD*)	*CI*		*M* (±*SD*)	*CI*			*df*	*F*	*p*	η_p^2
Counting backwards												
			Lower	Upper		Lower	Upper	Time	1	1.982	.173	0.079
IG	14	3.86 (±4.07)	1.50	6.22	5.64 (±4.89)	3.06	8.22	Group	1	0.171	.683	0.007
CG	11	7.18 (±4.51)	4.52	9.85	3.72 (±4.36)	0.82	6.64	Time × Group	1	19.542	<.001**	0.459
Cognitive status (MoCA)												
			Lower	Upper		Lower	Upper	Time	1	3.785	.061	0.106
IG	16	10.31 (±6.87)	7.00	13.63	11.06 (±7.50)	7.40	14.73	Group	1	0.053	.819	0.002
CG	18	12.50 (±6.18)	9.38	15.63	9.94 (±6.93)	6.49	13.40	Time × Group	1	12.687	.001*	0.284

Note. IG = intervention group; CG = control group; MoCA = Montreal Cognitive Assessment.
* $p < .05$.
** $p < .01$.

the help of the mentoring nurses in scale steps from 0 to 15 points depending on the item. A total score was created as the sum of all items. Scores ranged from 0 (totally dependent) to 100 (fully independent) (Mahoney and Barthel, 1965).

The Modified Functional Reach Test (Lynch et al., 1998) assessed the dynamic sitting balance. The test was executed in a sitting position with feet positioned stable on the ground. The participant was sitting against the back of a chair next to a wall reaching forward as far as possible without losing balance. The difference between the arm's length and maximal forward reach distance in cm was measured with a scale attached to the wall. For every participant, one measurement was conducted.

Table 5

Descriptive values and F-statistics for the 2 Time (Pre, Post) × 2 Groups (IG, CG) mixed measures ANOVAs for the psychosocial outcomes physical well-being (SF-12 physical), mental well-being (SF-12 mental), satisfaction with life (SWLS) and depression status (CES-D).

Physical well-being (SF-12 physical)

	n	Pre			Post			F-statistics				
		M (±*SD*)	*CI*		*M* (±*SD*)	*CI*			*df*	*F*	*p*	η_p^2
			Lower	Upper		Lower	Upper	Time	1	0.129	.722	0.004
IG	16	39.61 (±8.49)	34.48	44.75	43.44 (±9.73)	38.38	48.50	Group	1	0.391	.537	0.013
CG	16	40.90 (±11.41)	35.77	46.03	38.28 (±10.09)	33.22	43.34	Time × Group	1	3.669	.065	0.109

Mental well-being (SF-12 mental)

	n	Pre			Post			F-statistics				
		M (±*SD*)	*CI*		*M* (±*SD*)	*CI*			*df*	*F*	*p*	η_p^2
			Lower	Upper		Lower	Upper	Time	1	0.002	.968	<0.001
IG	16	53.73 (±7.56)	49.29	58.17	56.34 (±6.75)	51.76	60.92	Group	1	1.925	.176	0.060
CG	16	52.70 (±9.71)	46.26	57.15	50.24 (±10.74)	45.66	54.82	Time × Group	1	2.023	.165	0.063

Satisfaction with life (SWLS)

	n	Pre			Post			F-statistics				
		M (±*SD*)	*CI*		*M* (±*SD*)	*CI*			*df*	*F*	*p*	η_p^2
			Lower	Upper		Lower	Upper	Time	1	1.803	.191	0.063
IG	15	24.33 (±6.14)	20.63	28.04	24.13 (±6.41)	20.22	28.04	Group	1	0.569	.457	0.021
CG	14	23.93 (±7.82)	20.09	27.77	20.93 (±8.30)	16.88	24.98	Time × Group	1	1.380	.250	0.049

Depression status (CES-D)

	n	Pre			Post			F-statistics				
		M (±*SD*)	*CI*		*M* (±*SD*)	*CI*			*df*	*F*	*p*	η_p^2
			Lower	Upper		Lower	Upper	Time	1	0.672	.419	0.023
IG	16	5.19 (±5.12)	2.90	7.48	4.38 (±4.62)	2.35	6.40	Group	1	2.186	.150	0.070
CG	15	6.00 (±3.67)	3.64	8.36	7.73 (±3.11)	5.64	9.82	Time × Group	1	5.135	.031*	0.150

Note. IG = intervention group; CG = control group; SF-12 = short form of the health survey; SWLS = Satisfaction with Life Scale; CES-D = Center for Epidemiological Studies Depression Scale.

* $p < .05$.

The Purdue Pegboard Test (Tiffin and Asher, 1948) assessed the participants' clinical manual dexterity. The board consists of two parallel rows of 25 holes each and pins in cups located at the top of the board. Using both hands simultaneously the participants placed as many pins as possible in the holes within a 30 s time period in one trial. The average number of pins per hand was recorded.

Cognitive outcomes

The Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005) is a brief screening tool of global cognition to reveal mild cognitive impairment and an early stage of Alzheimer's disease. It was used to assess several cognitive domains, including short-term memory recall, visuospatial abilities, multiple aspects of executive functions, attention, working memory, language and orientation to time and place. The MoCA ranges between 0 and 30. A score of 26 or above is considered to be cognitively healthy. The average score for mild cognitive impairment is 22 (range 19–25) and the average score for mild Alzheimer's disease is 16 (11–21) (Nasreddine et al., 2005). Very low scores in this study were not used as an exclusion criterion.

To assess the cognitive domain working memory, a serial subtraction test (SST) was used. While the SST, as part of the Mini-Mental State Examination (Folstein et al., 1983) involves counting backwards in increments of seven, we adapted the incremental steps to one, in order to meet the level of cognitive function present in our study population. The numbers 200 and 300 were used as starting point and participants needed to count backwards for 15 s in one trial. For the SST the number of correct answers within 15 s was recorded. Subsequently correct subtractions after an error occurred were counted as correct answer. A clear standardized instruction of the test was given before the test started. The assessor asked the participants if they understood the instructions and therefore secured that the participants were able to conduct the task.

Psychosocial outcomes

The short form of the Health Survey SF-12 (Ware et al., 2002) was used to examine the health-related physical and mental well-being of the residents via twelve items in the domains: physical function (2 items), role limitations due to physical health problems (2 items), physical pain (1 item), general health (1 item), vitality (energy/fatigue; 1 item), social function (1 item), role limitations due to emotional problems (2 items), and mental health (psychological distress and psychological well-being; 2 items) (Ware et al., 2002). Composite scores for mental and physical well-being were calculated from the short form of the Health Survey SF-12 (Ware et al., 2002). Scores above 50 are above average and scores below 50 are below average. No missing values or imputations occurred.

The Satisfaction with Life Scale (SWLS) (Glaesmer et al., 2011) is an instrument with five questions and was used to measure global cognitive judgements of satisfaction with one's life on a seven-point Likert scale from 7 (total agreement) to 1 (no agreement at all). For the SWLS (Glaesmer et al., 2011) a total sum was calculated with a possible range from 5 to 35 points.

The Center for Epidemiological Studies Depression Scale (CES-D) (Radloff, 1977) has demonstrated validity for research conducted in elderly populations (Karim et al., 2014). The eleven-item questionnaire was used to screen for depressive symptoms and mood disorders. Answers were given on a scale ranging from "rarely/not at all" (0 points) to "sometimes" (1 point) and "mostly/all the time" (2 points). The scoring of positive items (questions 3 and 11) is reversed. For the CES-D (Radloff, 1977) a sum score out of the 11 items was calculated, ranging from 0 to 22.

Training modalities and feasibility criteria

To assess the intensity of strength and aerobic exercises and to provide an appropriate progression, instructors used the Borg Scale of Perceived Exertion (RPE) (Borg, 1998) during the training sessions aiming at a moderate intensity which corresponds to 12–14 points on the RPE scale.

The examination of acceptance was twofold: (1) To examine the acceptance of the intervention attendance of each participant was recorded and reasons for dropouts were documented. Minimum participation of 75% was required to be included in the evaluation. (2) Acceptance of the intervention content was examined by qualitative participants' group feedback and feedback of the nursing staff at the end of the 16-week intervention. The exercise instructor made notes to collect and analyze the qualitative data from participants and nursing staff.

2.8. Statistical analysis

Descriptive data are presented as percentage (sex), mean and standard deviation. First, all outcome values were tested for normal distribution using Kolmogorov-Smirnow-test.

For participants who completed both baseline and post training testing statistical comparison between pre- and post- training intervention was performed using a 2 × 2-factorial mixed measures analysis of variance (ANOVA), with Group (IG-CG) as between-subject factor and time (pre-post) as within-subject factors. The statistical analysis was performed with IBM SPSS Statistics (Version 25.0. Armonk, NY; IBM Corp.). For all ANOVAs, Greenhouse–Geisser adjustment was used in case the sphericity assumption was violated. By use of the Levene's Test, homogeneity of variances was asserted and, in case of violation, corrected p values were used. Effect sizes are reported as partial eta squared (η_p^2). In all statistical analyses p values ≤ .05 were regarded as significant.

Moreover, we conducted an intention-to-treat analysis with the whole group (including the seven dropouts of IG and the seven dropouts of CG) to avoid the risk of unbalanced groups at the end of the trial. Based on the study by Twisk et al. (2020), we carried out the intention-to-treat analysis with and without imputation.

3. Results

As visible in the participant flowchart (Fig. 1), data of 19 participants for each group, experimental and control, were analyzed. This sample was applied for pre- as well as for post measurement data.

3.1. Motor function outcomes

Within all four motor function outcomes (ADL, clinical manual

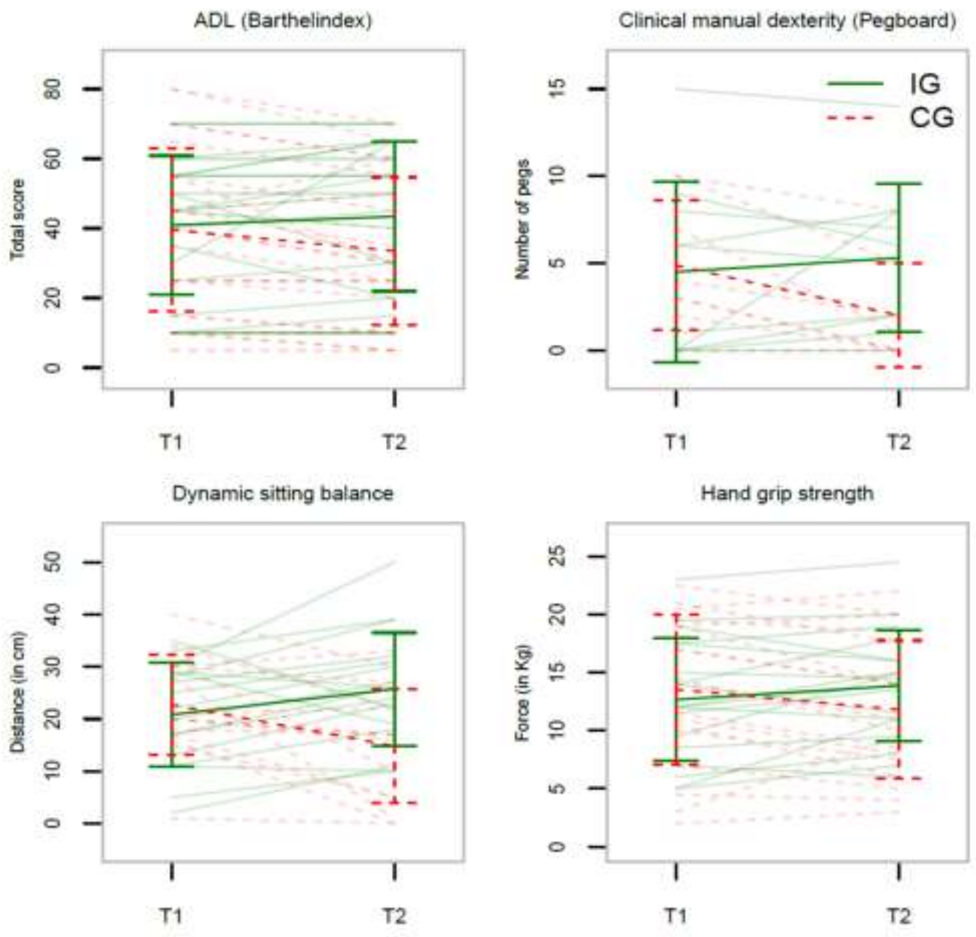

Fig. 2. Mean and SD (opaque lines) and individual changes (semi-opaque lines) for motor function outcomes in the IG (green solid lines) and wait-list CG (red dashed lines). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

dexterity, dynamic sitting balance, and hand grip strength) we found a significant time × group interaction (cf. Table 3 for description and statistics). In all tests, the IG improved its performance while the CG showed performance deteriorations from pre to post (cf. Table 3 & Fig. 2). For ADL (Barthel index) the IG averagely improved 2.5 (±1.54) points while the CG decreased by 6.09 (±2.22) points from pre to post. For clinical manual dexterity skills (Purdue Pegboard test), the IG averagely had 0.8 (±0.92) more pins pre to post while the CG decreased its manual dexterity by 2.88 (±0,74) pins. For dynamic sitting balance (modified functional reach test) the most distinct mean difference from pre to post within the IG (4.89 ± 0.92 cm) as well as the CG (−7.93 ± 1.36 cm) was observed. Finally, IG improved its hand grip strength by 1.19 (±0.49) kg from baseline to post measurement while the CG showed a decrease by 1.73 (±0.49) kg. All positive changes of the IG with respect to the CG were confirmed by significant interaction effects obtained from the mixed ANOVAs while no significant main effects were found for group or time (cf. Table 3).

3.2. Cognitive outcomes

Similar to the motor function outcomes, we were also able to show a significant time by group interaction for the cognitive outcomes (cf. Table 4 for descriptive data and statistics). Both cognitive outcomes (counting backwards (working memory) and cognitive status) revealed an improvement for the IG and a decrease in performance for the CG, illustrated in Table 4 and Fig. 3. When conducting the counting backwards task, the IG averagely accomplished an increase of 1.78 (±0.82) correct elements in 15 s from pre to post measurement. The CG declined their performance with 3.46 (±0.15) elements pre to post. For the cognitive status (MoCA) (Nasreddine et al., 2005), IG on a scale from 0 to 30 showed a mean increase of 0.75 (±0.63) points between measurements, while the CG decreased its performance by averagely 2.50 (±0.75) points. As for motor function outcomes, ANOVAs confirmed significant effects for group × time interaction, however not for any main effects of group or time (cf. Table 4).

3.3. Psychosocial outcomes

Concerning the psychosocial outcomes (cf. Table 5 for statistics and Fig. 4), the depression status (CES-D) (Radloff, 1977) was the only parameter showing a significant difference between groups over time, with a mean improvement of 0.81 (±0.5) points from pre to post for the intervention and a mean decline of 1.73 (±0.56) points for the CG. This was confirmed by a significant group × time interaction effect. All other psychosocial parameters either showed no changes (satisfaction with life; minus 0.2 ± 0.27 points averagely) or slightly improved (physical and mental well-being; plus 3.83 ± 1.24 points and plus 2.61 ± 0.81 points) for the IG and declined for the CG.

3.4. Training modalities and feasibility outcomes

In total, 92% of the IG accepted the intervention and regularly participated the training (attendance >75%). One participant died and one was unable to participate regularly (attendance <75%) until the end of the intervention due to severe cognitive decline. Additionally, five participants (two of IG and three of CG) declined the post measurements for no apparent reason and five participants (three of IG and two of CG) could not attend the post measurements due to illness. In the CG one participant died and one was unable to continue the study due to severe motor decline. In summary, 14 dropouts (27%, seven of IG and seven of CG) were recorded at follow-up. After 16 weeks (t2) n = 38 residents were included in the analysis.

The intention-to-treat analysis as well as the imputation strategy according to Twisk et al. (2020) did not reveal any significant differences in addition to the reported results.

Additionally, qualitative participants' group feedback and feedback of the nursing staff revealed that the tailored structure of the training and the individually adapted intensity with regard to the F.I.T.T. principles were well accepted. Most of the time, the RPE scale was a feasible tool to reach moderate intensity in the range of 12–14 points during the exercises. However, for some of the residents, the RPE scale was not eligible to control a moderate intensity due to cognitive limitations. In those cases, exercise intensity was estimated on participants' respiratory response to dialogue during exercise performance. No harms or adverse events occurred during the training.

4. Discussion

The primary aim of the study was to investigate the effectiveness of a CBE intervention for nursing home residents who are unable to walk for improving (or sustaining) resources in the domains motor function, cognition and psychosocial well-being. We expected the CBE intervention to be effective with respect to maintaining the residents' resources and their performance in these domains. The results showed that the IG increased their performance within all four tests of motor function (ADL, clinical manual dexterity, dynamic sitting balance, and hand grip strength), both cognitive tests (working memory and cognitive status) and within psychosocial outcomes (depression status and physical and

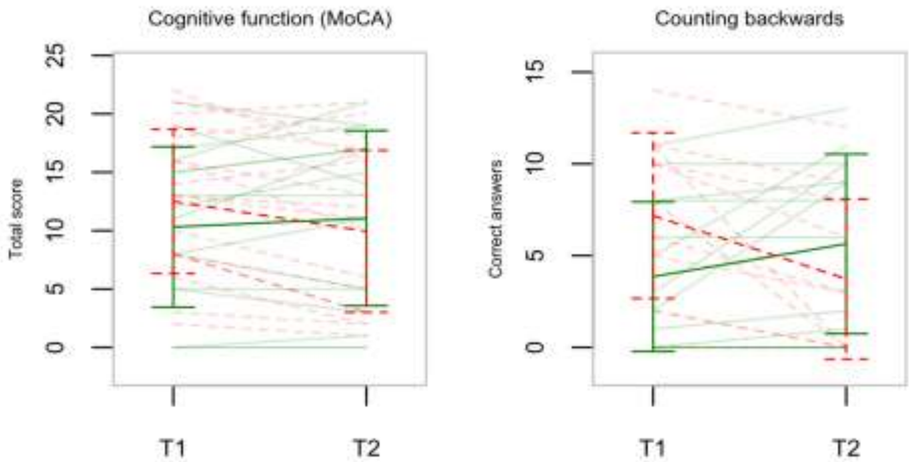

Fig. 3. Mean and SD (opaque lines) and individual changes (semi-opaque lines) for cognitive outcomes in the IG (green solid lines) and wait-list CG (red dashed lines). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

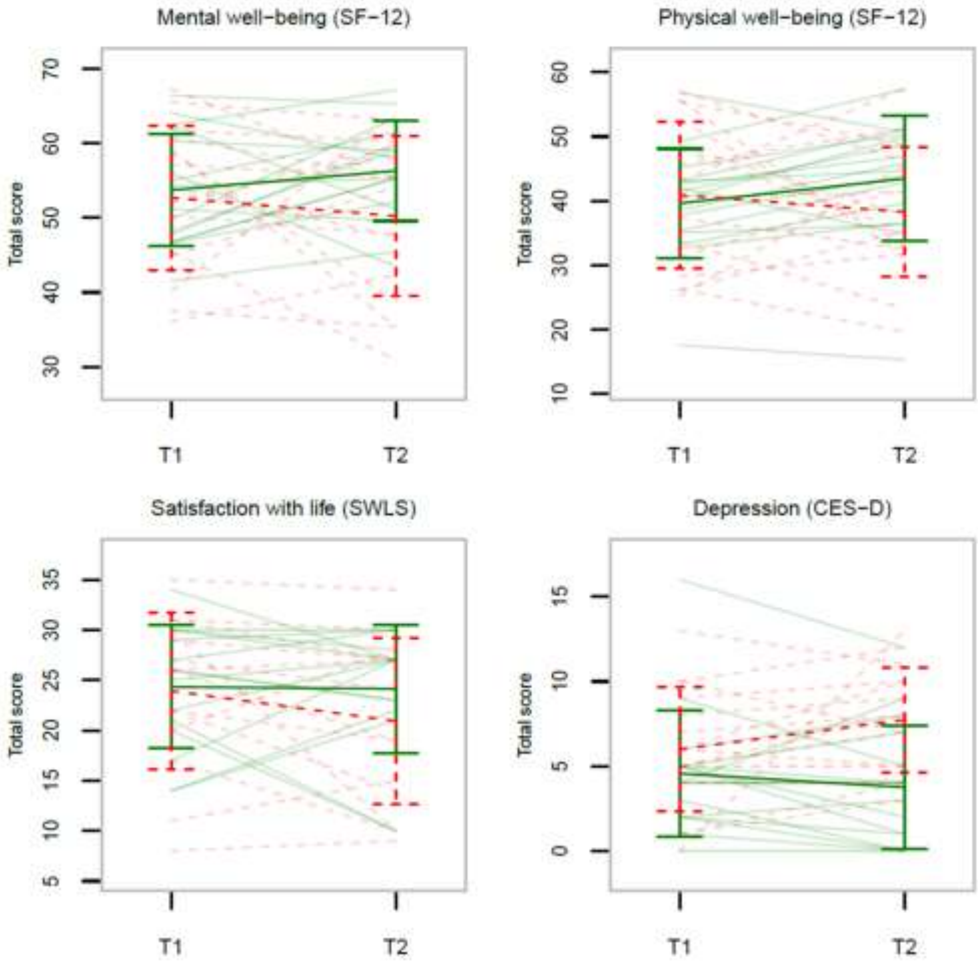

Fig. 4. Mean and SD (opaque lines) and individual changes (semi-opaque lines) for psychosocial outcomes in the IG (green solid lines) and wait-list CG (red dashed lines). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

mental well-being) while the CG showed continuous decrements over the course of 16 weeks. For one psychosocial parameter (satisfaction with life) the IG remained stable while the CG declined.

In line with findings by Masciocchi et al. (2019), who described a progressive decrease in hand grip strength (2.2% per month) and dynamic balance (2.8% per month), motor performance deteriorations in our CG might have resulted from an age-related loss of muscle function when being inactive. As the multicomponent CBE intervention was suitable to stabilize these motor functions and prevented a downward trend in the IG, the intervention can be considered as beneficial for nursing home residents, who are exposed to a severe age-related decline (Masciocchi et al., 2019). Analog to the motor function outcomes, the examined cognitive parameters (counting backwards and cognitive status with the MoCA) slightly improved in the IG and severely decreased in the CG. Concerning the psychosocial outcomes, a reduction in symptoms of depression was detected for the IG compared to an increase in depressive symptoms in the CG. The other psychosocial parameters either stayed on the same level (satisfaction with life) or improved (physical and mental well-being) in the IG, while all parameters declined for the CG. This is in line with previous findings, showing that these psychosocial parameters typically decline in elderly nursing home residents (Henskens et al., 2018; Scheidt-Nave et al., 2010). Hence, our first hypothesis that a multicomponent CBE intervention is able to improve motor functions for nursing home residents who are unable to walk can be accepted. In addition, the second hypothesis that the intervention is able to improve cognition can be accepted as well. Hypothesis three can be accepted since the psychosocial well-being either improved or remained stable within the IG.

Overall, the results of this RCT are in line with results from previous exercise studies investigating frail and multimorbid nursing home residents who are able to walk and revealed improvements in motor function (Grönstedt et al., 2013; Haritz Arrieta et al., 2018; Johnen and Schott, 2018; Kryger and Andersen, 2007; Weening-Dijksterhuis et al., 2011), cognitive function (Forbes et al., 2013), and well-being (Chin A Paw et al., 2004; Yümin et al., 2011). Therefore, the results support our assumption that, in addition to ambulatory nursing home residents, multicomponent CBE interventions can be conducted with, and are effective in a similar population with nursing home residents who are unable to walk. The exercises conducted for this study were beneficial for the target group despite their reduced mobility. Moreover, the increased functional abilities can be assumed to be associated with a better performance in ADL (Covinsky et al., 2003) which might also have additional positive effects on satisfaction with life and well-being (Kehyayan et al., 2016).

In particular residents who are unable to walk are often at risk of being socially isolated due to their limited mobility. A previous study suggested a possible association between physical inactivity, cognitive decline, and social isolation in nursing home residents as described by

Schrempft et al. (2019). Therefore, effects of inactivity and social isolation might reinforce each other and lead to a vicious circle. The results of our study showed a cognitive decline for the inactive and possibly more socially isolated CG without training. Thus, the assumption of a possible association between physical inactivity, cognitive decline, and social isolation can be confirmed. With respect to acceptance and feasibility and compared to a program for residents who were able to walk with a similar multicomponent structure (Bischoff et al., 2020; Cordes et al., 2019), the CBE program was equally accepted and well tolerated by the nursing home residents who are unable to walk. 92% of the residents participated regularly and no harms or adverse events occurred during the intervention. A reason for the high level of acceptance might be the tailored structure of the training and the individually adapted intensity. Therefore, future interventions should be tailored to the needs of the residents and consider their individual functional abilities.

In the current intervention we explicitly added motor-cognitive exercise as earlier studies with community dwelling older adults (Wollesen et al., 2020; Wollesen and Voelcker-Rehage, 2014) and people with dementia (Schwenk et al., 2010). These combined cognitive-motor interventions have been shown to be feasible and might have the highest impact to improve motor and cognitive function simultaneously (Levin et al., 2017). The results of our study indicate that these motor-cognitive dual-task exercises might also be effective when conducted with residents who are unable to walk. Many ADL such as moving independently with the wheelchair while orienting, dressing or handling a cup of tea while talking require motor and cognitive performance simultaneously. One study showed that chair-based motor exercises combined with mental and memory exercises were effective in improving cognitive function of nursing home residents (Thurm et al., 2011). A comparable improvement of cognitive performance was also demonstrated by our results. However, a recent study by Rezola-Pardo et al. (2019) showed that the combination of cognitive training and multicomponent training does not seem to be superior to simple multicomponent training. As the number of studies with dual-task CBE tailored for residents who are unable to walk is rare, further research is desirable in order to investigate the possible potential of dual-task CBE e.g., including upper limb tasks according to Voelcker-Rehage and Alberts (2007).

Positive benefits of exercise in old age are broadly accepted. However, many aspects concerning the required training intensity to gain effects on physical function, cognition and psychosocial well-being are yet to be clarified (Mayer et al., 2011). Precise information for training modalities, e.g. duration, frequency, and how to adjust a suitable intensity to provide a sufficient stimulus for muscle adaptation is missing. In order to deal with this lack of standardized training modalities the program was structured according to the F.I.T.T. principles (Garber et al., 2011), to general recommendations from the IAGG for older adults in long term care (de Souto Barreto et al., 2016) and to interventions for frailty (Freiberger et al., 2016). The results of this study indicate that 60 min per training session, two times per week, for a total of four months are feasible and effective modalities for CBE in nursing home settings and thus correspond to the recommendations of the IAGG (de Souto Barreto et al., 2016). In rehabilitation settings, the Borg scale has been shown to provide a valid method to achieve target exercise intensity (Stuckenschneider et al., 2020). Therefore, in our study the intensity was controlled using the Borg scale for perceived exertion (Borg, 1998) as well, targeting a scale value of 12–14 for moderate intensities. Additionally, a constantly adapted progression was adjusted by raising exercise sets, level of difficulty, and repetitions. In cases where perceived ratings of exertion could not be used due to cognitive limitations, exercise intensity was estimated on participants' respiratory response to dialogue during exercise performance. The difficulty of controlling the intensity during exercise interventions for people with cognitive limitations has also been reported in other studies (Pereira et al., 2018; Stuckenschneider et al., 2020). With the successful application of the Borg scale to adjust the intensity, a progressive training can, however, lead to physiological adaptations even in very old age.

In this study, we limited exercise intensities to moderate. Previous studies with ambulatory older adults also showed effectiveness for high intensity walking and standing exercises (Conradsson et al., 2015; Littbrand et al., 2009; Rosendahl, 2006). Exercises at higher intensities might also be effective and feasible for a non-ambulatory target group like the one in this study. On the contrary, exercises with high intensity might have a certain risk of cardiovascular events for those who do not exercise regularly (Franklin et al., 2020) and should therefore be carried out with caution. Hence, we applied the controlled F.I.T.T. principles and dose parameters for the CBE program according to the results and recommendations of a previously conducted review (Cordes et al., 2020). Nevertheless, more research concerning dose-response relationships is needed to support these findings and to contribute to the development of specific guidelines for future CBE interventions for nursing home residents including those who are unable to walk.

The findings of this study contribute to research concerning exercises for nursing home residents who are unable to walk – a field which is still underrepresented in the existing literature. A reason for this research gap might be the fear of overloading and injuries when applying the same principles for exercises existing for ambulatory adults. Another reason might be the false assumption that due to frailty and immobility interventions would not benefit motor functions of the participants (Ferrucci et al., 2004). Therefore, simple repetitive range of motion exercises without progression are typically administered, with the goal to maintain social participation and a basic level of physical activity rather than aiming at regaining function and independence. However, there is no conclusive evidence for this assumption. On the contrary, the results of this study indicate that even institutionalized and frail older adults who are unable to walk benefit from a multicomponent CBE intervention.

4.1. Limitations

Next to the strengths of this study e.g., the assessment and data collection were done by blinded assessors, there are some limitations that need to be addressed. First, there might be a possible bias in data of the Barthel Index because it was assessed by the caregivers who were not blinded. Due to daily changes of the responsible nurses it was not possible to control which caregiver was aware of the study and the intervention. Therefore, caregivers who were aware of a resident's participation might have tended to expect and perceive a better performance in ADL and may therefore have rated a higher score on the Barthel Index. Moreover, due to ethical reasons the nursing home residents were aware of receiving or not receiving the intervention and therefore they were more likely to provide biased answers during the assessments. This could particularly affect the answers within the questionnaires about physical and mental health. Although the random allocation was stratified by age, the age range of 22 years might have caused an effect on motor function responses. This should be considered in the stratification of the groups in future research. Nevertheless, this age range represents the real-life conditions in nursing home setting. Independent of age they are in the need of care due to multimorbidity.

Moreover, participation was voluntary and the main reason for exclusion was that residents refused to participate. Hence, the majority of the participants might associate a positive connection between exercise and health. Therefore, they might have been biased. We could not be sure whether participants who refused participation would also benefit from physical activity. Finally, the dropout rate was 27% at follow-up measurements for different known and unknown reasons. The main reason was that individuals felt unwell or appeared to be physically or mentally too unstable on the day of the assessment. This indicates a high relevance of day-to-day fluctuations within nursing homes. Nevertheless, given the expected dropout rate of 30% for nursing home residents, the sample size achieved can be judged positively and fulfills the previous calculated power.

Another interesting aspect might be the association between the participants level of education and the cognitive function. Unfortunately, the level of education was not assessed in this study and should be considered in future research.

5. Conclusions

A multicomponent CBE intervention was able to improve motor functions (hand grip strength, sitting balance, clinical manual dexterity, ADL), cognition (cognitive status, working memory) and psychosocial resources (symptoms of depression (CES-D)) in nursing home residents who are unable to walk. Moreover, other psychological factors such as satisfaction with life (SWLS) and physical and mental well-being (SF-12) remained stable within the IG. Although we could not find an increase in these factors, we still consider the absence of a deterioration to be a good result. The CG not participating in the exercise intervention showed a significant decrease in all of the investigated parameters after 16 weeks. Thus, we concluded that a multicomponent CBE program that takes F.I.T.T. principles into account and progressively increases the intensity can lead to physiological adaptations even in very old age. The results of this study are important for developing and conducting appropriate CBE interventions and evidence-based guidelines for nursing home residents including those who are unable to walk. The study results might encourage caregivers, clinicians and policymakers to further differentiate the heterogeneous group of nursing home residents concerning mobility aspects and to include CBE as a feasible program for health promotion. More research and interventions might also help the subpopulation of frail nursing home residents with mobility restrictions to prevent further decline of functional performance and maintain independence in ADL for a better physical and mental well-being.

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Ethics approval

The trial was conducted in agreement with the principles of the Declaration of Helsinki and the guidelines of Good Clinical Practice (GCP). The ethics committee of the Hamburg Chamber of Physicians, Germany, approved the previously published study protocol (Cordes et al., 2019) (PV5762).

Consent to participate

All participants and their legal guardians were informed about the study goals. Written informed consent was obtained from all participants or their legal guardians prior to the study enrollment according to the Declaration of Helsinki. Participants as well as their relatives or legal guardians were able to withdraw consent at any time.

Consent for publication

Personal information about the study participants will not be published. All participant information and data were stored securely and identified by a coded ID number only to maintain participants' confidentiality.

Availability of data and material

Data can be obtained from the corresponding author upon reasonable request.

Code availability

Not applicable.

CRediT authorship contribution statement

Thomas Cordes: Conceptualization, methodology, validation, formal analysis, investigation, writing - original draft, writing - review & editing, visualization, project administration.
Katharina Zwingmann: Investigation, writing – results, writing – review & editing, visualization.
Julian Rudisch: Formal analysis, investigation, writing - review & editing, visualization.
Claudia Voelcker-Rehage: Conceptualization, methodology, validation, writing - review & editing.
Bettina Wollesen: Conceptualization, methodology, validation, supervision of formal analysis, supervision of Writing - original draft, writing - review & editing.

Declaration of competing interest

The authors declare that they have no conflicts of interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.exger.2021.111484.

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Anhang H: Lebenslauf

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- Wissenschaftliche Begleitung bewegungstherapeutischer Interventionen
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Anhang G: Eidesstattliche Erklärung

Eidesstattliche Erklärung nach § 7 (4) der Promotionsordnung des Instituts für Bewegungswissenschaft der Universität Hamburg vom 18.08.2010

Hiermit erkläre ich an Eides statt,

1. dass die von mir vorgelegte Dissertation nicht Gegenstand eines anderen Prüfungsverfahrens gewesen oder in einem solchen Verfahren als ungenügend beurteilt worden ist.

2. dass ich die von mir vorgelegte Dissertation selbst verfasst, keine anderen als die angegebenen Quellen und Hilfsmittel benutzt und keine kommerzielle Promotionsberatung in Anspruch genommen habe. Die wörtlich oder inhaltlich übernommenen Stellen habe ich als solche kenntlich gemacht.

Hamburg, 27.07.2022

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(Ort, Datum)

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(Thomas Cordes, M. Sc.)