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Spatiotemporal gait parameters during dual task walking in need of care elderly and young adults

A cross-sectional study

Introduction

How to examine changes in temporal and spatial gait parameters during walking has been insufficiently clarified in needy elderly individuals or the elderly in need of care, such as (pre)frail elderly and elderly people with mobility disabilities [1]. In ageing, attention resources are increasingly focused on walking and maintaining the postural control is neglected compared to younger people [2]. Walking is more complex than it seems to be and is a daily sensorimotor task, which simultaneously requires complex interactions between motor, sensory and cognitive control functions; however, the simultaneous processing of all information sources is hindered. During walking the body must always be able to react to environmental influences by balancing reactions [3, 4] and in order to do this muscle strength, balance and cognition are required [3]. It is noticeable that elderly individuals are unable to automatically adapt their gait to the environment [5]. Ageing is associated with loss of muscle strength and reduced balance. During walking, attention is required to maintain balance and not to observe the surroundings [6]. Due to this loss of resources it is no longer possible to adequately react to altered external stimuli. This results in a decrease in walking speed of elderly individuals [7] and this condition leads to an increased risk of falling [8]. For this reason, it is necessary to evaluate cognitive capacity during walking in elderly individuals particularly in deconditioned persons, such as those with mobility disabilities.

Priest et al. [9] examined gait variability of young and older women and found that dual tasking increased gait variability in both groups but gait variability was significantly higher in older women. Kressig and Beauchet [10] described that increased gait variability is associated with deteriorating cognition, a lower degree of automation of walking movement and an increased mobilization of attention resources; however, in younger adults a simultaneous dual tasking does not result in a loss of resources. The gait becomes severely impaired and this may result in an increased risk of falling. It is crucial to evaluate which spatiotemporal gait parameters are used during single task (ST) and dual task (DT) walking in order to identify assessment procedures for rehabilitation or treatment effects [11]. Furthermore, in published studies the distance used for assessing spatiotemporal gait parameters has tended to be too short [12]. Najfi et al. [13] postulated that a distance of at least 20 m is required for a reliable measurement of gait variability; however, data from gait investigations in elderly individuals in need of care are still lacking [1].

This cross-sectional study was conducted to examine the explanations listed due to the very limited number of studies on elderly individuals in need of care. The aim was to collect data on gait speed, cadence and stride length cycle variability over a walking distance of 20 m in the elderly in need of care and then to obtain initial approximate values to standardize a protocol of gait assessment in the elderly in need of care under single and dual task conditions. Moreover, the impact of ST and DT on gait parameters was investigated. In addition, data for gait speed, cadence and stride length cycle variability in young adults were collected as reference data.

Purpose and method

Design

This cross-sectional study was based on the publication guidelines in the STROBE statement [14], which represent the recommendations on manuscript preparation, such as title, abstract, introduction, methodology, results and discussion.

Participants

The study was carried out in the elderly in need of care group: participants in the older group were elderly individuals in need of care (**Table 1**) defined as a situation when an elderly individual is permanently dependent on assistance or support in everyday activities (e.g. dressing, body hygiene, eating, using the bathroom, mobility, planning the day and social contacts). Participants were recruited from a community dwelling home in the Canton of Bern, Switzerland. The inclusion criteria were age older than 80 years, in need of care, able to walk over 20 m with or without aids, classified as having a resident assessment instrument for nursing homes (RAI) performance level >0 and having a mini-mental state examination (MMSE) score >16. Exclusion criteria were neurological and muscular diseases, unstable

Table 1 Anthropometric data of the study cohort (mean ±standard deviation)

	N	Age (years)	Height (cm)	Weight (kg)	Women/men	Aids
Young group	16	22.3 ± 2.5	168.4 ± 5.1	62.0 ± 6.9	8/8	–
Elderly in need of care group	16	85.5 ± 0.6	161.9 ± 11.9	64.5 ± 15.4	10/6	16

cardiovascular disease, psychiatric disorders, fever and acute pain. Need of care was defined as whether the elderly person depends permanently on assistance or support in everyday activities, such as dressing, body hygiene, eating, use of the bathroom, mobility and planning the day [15] with the background knowledge that a person's dependence on care markedly increases after the age of 75 years [15].

Participants in the younger group were healthy students from the Bern University of Applied Sciences. All participants of both groups provided informed consent. The local ethics committee of the Canton of Bern approved the study protocol (KEK Nr. 147/12).

Instrumentation

Gait speed (m/s), cadence (steps/min) and stride length cycle variability (%) were collected with the inertia sensor RehaWatch® (Hasomed Magdeburg, Germany). Previous studies have shown a good concurrent validity for healthy participants ($n = 1860$, age range 5–100 years) [16] and a high reliability with an ICC ranging from 0.69 to 0.96 during normal walking in healthy participants ($n = 44$, range 20–30 years) [17]. The RehaWatch® system allows acceleration and angular velocity to be measured [16–18]. The inertia sensors were fixed at the height of the left and right lateral malleolus via a holder. Each inertia sensor contains three accelerometers and three gyroscopes which capture the foot movement in six degrees of freedom (three translational and three rotational). The accelerometers have a measuring range of ± 4 g and the gyroscopes of ± 700°/s. Measured data were sampled with a frequency of 500 Hz.

Data detection

The gait parameters gait speed (m/s), cadence (steps/min) and stride length cycle variability (%) were calculated from the RehaWatch®. Gait speed is the distance travelled divided by the walking time (m/s) and cadence is the number of strides per minute. Stride length is the distance that one part of a foot travels between the same instant in two consecutive gait cycles. Stride lengths were indexed by the coefficient of variability (CV) and are defined as the change in stride length between each stride (SD/meanx100) [10].

Test procedure

The participants wore comfortable shoes and leg length was measured from the trochanter major to the lateral malleolus. The trial began and ended at a marked tape point on the floor approximately 2 m from the start and end of the 20 m walkway. The reason for this procedure was so that acceleration and deceleration occurred before and after the walkway. Each participant was positioned at the starting point and was assessed during walking under four different conditions:

1. The participant was asked to walk at a self-selected walking speed as a single task. The participant received the important information: do not speak and try not to stop walking during the measurement. The participant was briefed to walk like you would when taking a letter to the mailbox.
2. The participant was asked to walk at a self-selected walking speed with an additional cognitive task under dual task conditions. The participant had to walk and count backwards aloud in steps of seven, five or three, depending on the ability. The participants were briefed to try to walk and count at the same time. Do not favor one task over the other but try to perform these concurrently.
3. The participant was asked to walk at the fastest walking speed possible. The participant received the important information: do not speak and try not to stop walking during the measurement.
4. The participant was asked to walk at the fastest walking speed possible with an additional cognitive task under dual task conditions. The participant had to walk and count backwards aloud in steps of seven, five or three depending on the ability. The participant was briefed to try to walk and count at the same time. Do not favor one task over the other but try to perform these concurrently.

Statistical analysis

Descriptive statistics were used to characterize the parameter of gait speed, cadence and stride length cycle variability and mean, standard deviation (SD), median, interquartile range (IQR) and CV in the elderly in need of care group and the young group.

A Wilcoxon rank sum test was used to determine differences within and Mann-Whitney U-test between the age groups during single task and dual tasks for the parameter gait speed, cadence and stride length cycle variability. The significance level was defined at $\alpha = 0.05$. In order to appreciate the context of the qualitative data, the intraclass correlation coefficient ($ICC_{(2,1)}$) was applied and interpreted following Landis and Koch's [19] benchmark, where >0.80 corresponds to almost perfect reliability, from 0.61 to 0.80 substantial reliability, from 0.41 to 0.60 moderate reliability, 0.21–0.40 fair reliability, < 0.20 slight reliability and < 0.0 poor reliability. The statistical analysis was performed using the statistical program R version 3.1.2 (Softliste.de, Berlin, Germany).

Results

In this cross-sectional study a total of 32 participants ($n = 16$ elderly and $n = 16$ young adults) could be recruited and were analyzed (**Table 1**). The ICC values during normal walking showed moderate to substantial reliability for the need of care group and are presented in **Table 2**.

Gait speed is depicted in **Table 3**. The average speed hardly differs between walking at a self-selected walking speed

Abstract · Zusammenfassung

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Spatiotemporal gait parameters during dual task walking in need of care elderly and young adults. A cross-sectional study

Abstract

Background. Up to now there have only been marginal data in the elderly in need of care regarding spatiotemporal gait parameters during single (ST) and dual tasking (DT).
Aim. The aim of this study was to allocate data for gait speed, cadence and stride length cycle variability in the elderly in need of care and in young adults during ST and DT, to compare the two groups and to demonstrate the impact of ST and DT on gait parameters.
Material and methods. This cross-sectional study investigated a group of 16 young healthy adults (mean age 23.0 ± 2.5 years) and a group of 16 elderly persons in need of care (mean age 85.5 ± 0.6 years). The RehaWatch® system was used to collect the spatiotemporal gait parameters cadence, speed and stride length. The participants completed four different measurements during normal walking and fast walking during ST and DT over a walking distance of 20 m. The Wilcoxon rank sum test and Whitney-U test were used for statistical analysis.
Results. Gait speed (ST and DT: $p < 0.001$), cadence (ST and DT: $p < 0.001$) and gait variability (ST: $p = 0.007$, DT: $p = 0.003$) were significantly reduced in the elderly in need of care group compared to the young group. The gait speed in the elderly in need of care group decreased from normal to fast walking (ST = – 2.8 %, DT = – 12.2 %) compared to the young group (ST = 31.5 %, DT = 25.2 %).
Conclusion. The results of this study are comparable with the results of existing studies, which investigated falling and non-falling participants. Elderly people in need of care cannot increase the normal gait speed.

Keywords
Attention physiology · Frailty · Gait parameters · Cross-sectional study · Disability evaluation

Raum-Zeit-Gangparameter während Doppelaufgaben bei pflegebedürftigen älteren und jungen Menschen. Eine Querschnittstudie

Zusammenfassung

Hintergrund. Bisher gibt es kaum Daten von pflegebedürftigen älteren Menschen bezüglich Gangparameter während Einfach- (EA) und Doppelaufgaben (DA).
Ziel. Das Ziel dieser Studie war es, Gangparameter wie Gehgeschwindigkeit, Kadenz und Gangvariabilität der Doppelschrittlänge bei pflegebedürftigen älteren und jungen gesunden Probanden zu erheben, innerhalb der und zwischen den Gruppen zu vergleichen und die Auswirkungen von EA und DA auf die Gangparameter aufzuzeigen.
Material und Methoden. In dieser Querschnittstudie wurde eine Gruppe von 16 jungen gesunden (23,0 ± 2,5 Jahre) und eine Gruppe von 16 pflegebedürftigen Probanden (85,5 ± 0,6 Jahre) untersucht. Mit Hilfe des RehaWatch®-Systems wurden Gehgeschwindigkeit, Kadenz, und Gangvariabilität der Doppelschrittlänge erhoben. Hierbei wurden 4 verschiedene Messdurchgänge während normalen und schnellen Gehens unter EA und DA auf einer Gehstrecke von 20 m absolviert. Für die statistische Auswertung wurden der Wilcoxon-Rang-Summentest und der Mann-Whitney-U-Test verwendet.
Ergebnisse. Gehgeschwindigkeit (EA und DA: $p < 0{,}001$), Kadenz (EA und DA: $p < 0{,}001$) und Gangvariabilität der Doppelschrittlänge (EA: $p = 0{,}007$, DA: $p = 0{,}003$) sind bei der pflegebedürftigen Gruppe signifikant niedriger in der Gruppe der jungen Probanden. Die Gehgeschwindigkeit in der pflegebedürftigen Gruppe reduzierte sich vom normal schnellen zum schnellen Gehen (EA = – 2,8 %, DA = – 12,2 %) im Vergleich zur jungen Gruppe (EA = 31,5 %, DA = 25,2 %).
Schlussfolgerung. Die Ergebnisse dieser Untersuchung sind vergleichbar mit denen früherer Untersuchungen in denen ältere Probanden nach Sturzereignissen und jüngere Probanden untersucht wurden. Pflegebedürftige Ältere können ihre normale Gehgeschwindigkeit nicht mehr steigern.

Schlüsselwörter
Aufmerksamkeitsphysiologie · Gebrechlichkeit · Gangparameter · Querschnittstudie · Evaluierung von Behinderungen

and walking at the fastest walking speed in the need of care group.

Table 4 illustrates significant differences ($p < 0.001$) for all task situations between both groups for cadence.

Stride length cycle variability indicates high values in the need of care group and significant differences to the young group (**Table 5**).

Discussion

The goal of this cross-sectional study was to collect data on gait speed, cadence and stride length cycle variability over a walking distance of 20 m in the elderly in need of care and then to obtain first approximate values to standardize a protocol of gait assessment in the elderly in need of care during ST and DT conditions. Furthermore, the impact of ST and DT on gait parameters was investigated. In addition data on gait speed, cadence and stride length cycle variability in young adults were collected as reference data.

It is remarkable that in all four tasks the gait speed was below 1.00 m/s in the elderly in need of care group. Kressig and Beauchet [10] found values of 0.73 ± 0.8 m/s in polyneuropathy patients (mean age 85.3 ± 4.1 years). The gait speed between walking at a self-selected walking speed and walking at the fastest walking speed decreased by 2.7 % in the elderly in need of care group. In contrast, the young group showed an increased gait speed between walking at a self-selected walking speed and walking at the fastest walking speed by 46 %. It can therefore, be assumed that elderly in need of care over 80 years cannot walk faster than the normal walking speed. Rogan et al. [20] found

Table 2 Intracorrelation coefficient ($ICC_{(2,1)}$) during walking at self-selected walking speed during single task (ST) and dual task (DT)

	Walking speed (m/s) ST	Walking speed (m/sec) DT	Cadence (steps/min) ST	Cadence (steps/min) DT	Stride length (m) ST	Stride length (m) DT
Young group	0.929	0.865	0.856	0.638	0.958	0.667
Elderly in need of care group	0.773	0.805	0.877	0.434	0.724	0.839

Table 3 The behavior of walking speed (m/s) during single task (ST) and dual task (DT) self-selected walking speeds and during fastest walking speeds during ST and DT in mean and standard deviation (± SD) and median and interquartile range (IQR)

	Young group (*n* = 16) mean ± SD median (IQR)	P-value within groups	Elderly in need of care group (*n* = 16) mean ± SD median (IQR)	P-value within groups	P-value between groups
Self-selected walking speed ST (m/sec)	1.39 ± 0.08 1.40 (1.33–2.07)		0.73 ± 0.23 0.68 (0.61–0.91)		< 0.001
Self-selected walking speed DT (m/sec)	1.43 ± 0.15 1.43 (1.35–1.49)	0.064	0.83 ± 0.28 0.81 (0.74–1.01)	< 0.001	< 0.001
Walking at fastest walking speed ST (m/sec)	2.03 ± 0.16 2.00 (1.92–2.07)		0.71 ± 0.23 0.66 (0.56–0.90)		< 0.001
Walking at fastest walking speed DT (m/sec)	1.79 ± 0.08 1.80 (1.74–1.85)	< 0.001	0.74 ± 0.26 0.74 (0.61–0.99)	0.734	< 0.001

Table 4 The behavior of cadence (steps/min) duringsingle task (ST) and dual task (DT) self-selected walking speeds and during ST and DT fastest walking speeds in mean and standard deviation (± SD) and median and interquartile range (IQR)

	Young group (*n* = 16) mean ± SD median (IQR)	P-value within groups	Elderly in need of care group (*n* = 16) mean ± SD median (IQR)	P-value within groups	P between groups
Self-selected walking speed ST (steps/min)	121.84 ± 4.47 122.44 (119.23–124.41)		103.56 ± 13.11 102.30 (98.68–113.15)		< 0.001
Self-selected walking speed DT (steps/min)	125.06 ± 6.92 125.18 (122.88–128.59)	0.095	111.08 ± 13.92 113.72 (107.50–121.78)	0.007	< 0.001
Walking at its fastest walking speed ST (steps/min)	157.80 ± 26.97 151.79 (146.43–157.33)		102.05 ± 13.16 100.85 (91.08–111.44)		< 0.001
Walking at its fastest walking speed DT (steps/min)	141.98 ± 6.00 140.19 (138.32–143.52)	< 0.001	103.37 ± 15.11 107.04 (99.04–113.63)	0.299	< 0.001

Table 5 The behavior of step length cycle variability (%) during single task (ST) and dual task (DT) self-selected walking speeds and during ST and DT fastest walking speed in mean and standard deviation (± SD) and median and interquartile range (IQR)

	Young group (*n* = 16) mean ± SD median (IQR)	P-value within groups	Elderly in need of care group (*n* = 16) mean ± SD median (IQR)	P-value within groups	P-value between groups
Self-selected walking speed ST step length cycle variability (%)	2.47 ± 2.75 1.60 (0.88–2.76)		10.29 ± 9.09 6.75 (4.14–15.29)		0.007
Self-selected walking speed DT step length cycle variability (%)	2.11 ± 1.56 2.03 (1.00–3.18)	0.980	11.65 ± 19.43 5.46 (2.55–6.64)	0.632	0.003
Walking at fastest walking speed ST step length cycle variability (%)	3.02 ± 2.35 2.67 (1.23–4.52)		6.86 ± 7.56 4.37 (1.64–7.98)		0.250
Walking at fastest walking speed DT step length cycle variability (%)	2.11 ± 1.80 1.76 (0.47–3.58)	0.376	9.35 ± 8.33 6.30 (2.75–11.74)	0.051	0.003

that the elderly in need of care were not able to walk at their fastest walking speed (0.79 ± 0.1 m/s walking at self-selected walking speed during ST: 0.79 ± 0.2 m/s). This may be because the elderly in need of care are afraid to or are no longer capable of walking at faster speeds. According to Fried et al. [21] a reduced velocity is associated with the criteria of frailty. In addition, age-related loss of muscle strength may contribute to a reduced walking speed [22]. On the basis that the elderly in need of care are not able to increase their normal walking speed, the parameters cadence and stride length cycle variability during fast walking should not be discussed due to the fact that findings are relevant for clinical application and the evaluation of spatiotemporal gait parameters in elderly in need of care should be done during normal walking. The cadence of the young participants corresponded to the predetermined reference value of 120 steps/min during normal walking without counting [23]. In contrast, the number of steps/min was 13.7 % lower in the elderly in need of care group. Hollman et al. [24] determined an average cadence value of 113.00 ± 8.0 steps/min in healthy adults (67–87 years). It can be assumed that older elderly (>80 years) exhibit a lower cadence (< 120 steps/min) and up to 80 years the cadence should remain unchanged [25].

The stride length cycle variability was 3-4 times higher during normal and fast walking among the elderly in need of care compared to young adults. Hausdorff et al. [26] compared young participants (24.6 ± 1.9 years) with non-fallen elderly (82.2 ± 4.9 years) and with fallen elderly (76.5 ± 4.0 years), who walk at a self-selected walking speed during the 6-min walking test. There were significant differences ($p < 0.001$) between the fallen and not fallen elderly and between the young participants. Hausdorff et al. [26] determined the gait duration cycle variability as unit of time in seconds. This current study determined stride length cycle variability as unit of length. Both variables are not to be compared to each other.

Priest et al. [9] found significant differences ($p < 0.001$) during walking with DT, where counting backwards from 100 in 3, 4 or 6 steps carried out by young and elderly participants. By random allocation of the numerical series a learning effect has been avoided. Participants had to perform an unprepared counting task and thus a new situation is created which comes close to everyday life. In the present study the learning effect was minimized by the random allocation of the number when beginning counting.

High gait variability correlates with a high risk of falling [27]. Gschwind and Bridenbaugh [25] indicated a doubled risk of falling in the next 6 months, when a variation of the step length of 1.7 cm exists. However, Maki [27] specified a stride length difference of < 2 cm. In the present study 62.5 % (10 out of 16) of frail subjects had a stride length difference of >1.7 cm and therefore twice the risk of falling. Based on the findings of Gschwind and Bridenbaugh [25], it can be assumed that 10 out of 16 participants have a twofold risk of falling in the next 6 months during DT performance. This study did not prove the hypotheses that gait variability is a risk factor for falling. Future studies should include this point in a longitudinal study.

Conclusion

This study investigated the effects of ST and DT conditions during normal and fast walking on quantitatively measured spatiotemporal gait parameters in the elderly in need of care. The elderly in need of care group showed a slower cadence and walking speed and higher stride length variability during walking at self-selected walking speeds in ST and DT compared to young adults. The elderly in need of care are unable to increase their normal walking speed; therefore, fast walking measurements are not relevant for clinical implications. Verghese et al. [28] described that a decreased gait speed is associated with increased gait instability and thus with an enhanced risk of falling. In future, studies should be designed as long-term studies and must be constructed in terms of the data collected on gait parameters and the number of falls to determine what kind of care the elderly need.

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Compliance with ethical guidelines

Conflict of interest. S. Agner, J. Bernet, Y. Brülhart, L. Radlinger and S. Rogan state that there are no financial or personal conflicts of interest in relation to this article or any other organizations or people.

All participants in this study provided informed consent. All studies on humans described in this manuscript were carried out with the approval of the local ethics committee of the Canton of Bern (KEK Nr. 147/12) and in accordance with national law and the Helsinki Declaration of 1975 (in its current revised form).

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Gerontologisch und geriatrisch orientierte Pflege auf Hochschulniveau

Neuer Start zum 1. April 2016 des Kontaktstudiengangs Gerontologie und Geriatrie

Das Bewusstsein für eine gerontologisch und geriatrisch orientierte Pflege hat sich in den letzten Jahren deutlich verstärkt. Die selbständige und autonome Lebensführung älterer Menschen mit ihren spezifischen Bedürfnissen gewinnt zunehmend an Bedeutung. Deren Pflege gestaltet sich deshalb komplex und bedarf ergänzender Qualifikationen. Deshalb bietet das Studienzentrum für Gesundheitswissenschaften & Management der Dualen Hochschule Baden-Württemberg Stuttgart eine neue Qualifizierungsmöglichkeit im Rahmen eines Kontaktstudiums "Gerontologie und Geriatrie", beginnend ab dem 1. April 2016, an. Das Kontaktstudium richtet sich an beruflich qualifizierte Pflegekräfte (auch ohne Hochschulzugangsberechtigung), die sich beruflich weiterentwickeln und ein differenziertes Wissen für die geriatrische und gerontopsychiatrische Pflege aneignen möchten. Der Abschluss erfüllt die abrechnungsrelevanten Anforderungen für den Arbeitgeber entsprechend der OPS Regelungen. Das Modul wurde gemeinsam mit dem Bundesverband Geriatrie e.V. entwickelt und ist von diesem als Teil der Zercur Geriatrie Fachweiterbildung Pflege zertifiziert. Mit einer Dauer von sechs Monaten ist der berufsbegleitende Kontaktstudiengang in kompakten Präsenzterminen von 2-4 Tagen im Monat organisiert. Abgeschlossen wird der gebührenfreie Studiengang mit einem Zertifikat und 10 ECTS-Punkten (Leistungspunkten). Anmeldungen zum Kontaktstudiengang sind ab sofort möglich.
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Quelle: www.dhbw-stuttgart.de/pflegewissenschaft