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Is the use of pedometers feasible for identifying the volume and intensityof a balance specific exercise programme for older adults

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Is the use of pedometers feasible for identifying the volume and intensity of a balance specific exercise programme for older adults

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A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

Background: Exercise programmes consisting of stepping were found to significantly reduce incidence of falls in the elderly. The aim of this case study was to evaluate the feasibility of step counts and to identify a specific dose, i.e. the amount and intensity of stepping during a multicomponent balance specific exercise programme.

Material and methods: Thirty fit community-dwelling older adults (69.7 ±6.2 years) participated in the study. The number of steps and the intensity of stepping per training unit was recorded with StepWatch pedometers.

Results: The average recorded number of steps per one-hour training unit was 1100 ±215. The intensity level of the activity was on average high for 43.6 ±16.6% of the unit time and moderate for 45.9 ±14.2% of the unit time, whereas only 9.9% ±3.9 of the unit time was in the low level range.

Conclusions: The use of pedometers, i.e. step counts, is feasible to monitor the intensity of the training as well as the volume and progression if needed for the balance specific exercise programmes. Additionally, this case study demonstrates that balance specific exercise programme can be organised in the way to facilitate balance by means of volitional and reactive stepping.

Key words: step count, balance training, elderly.

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INTRODUCTION

An increasing number of elderly adults, their need to sustain an active and healthy lifestyle, increasing costs for rehabilitation after falls are the principal driving force for policy makers, health authorities and clinicians to allocate financial and human resources to find effective programmes for fall prevention and balance enhancement or maintenance. Regular physical exercise has demonstrated its beneficial effect on increasing functional capacity [1], mobility [2], balance [3] and gait [4]. Various exercise programmes for balance enhancement or maintenance have been proposed and evaluated. There is no agreement in the literature regarding frail or fit community-dwelling older adults as to what kind of exercise intervention is the most effective for balance enhancement and fall prevention. Sherrington et al. [5] concluded that balance specific exercises, i.e. those programmes that challenge balance, are the most effective for fall prevention. Types of effective balance specific exercise programmes vary considerably: exercises on unstable and compliant surface [6, 7, 8] , dance [9], dual tasking [10] and multicomponent exercise programme [11, 12]. The results on the efficacy of multicomponent exercise programmes are conflicting, some authors reported their superiority compared to other types of exercise [1], while others concluded that multicomponent exercise programmes are not effective for enhancing stability of the centre of pressure (CoP) [13].

Based on the system framework, balance has nine components that are described by Sibley et al. [14]: static stability, underlying motor systems, functional stability limits, verticality, reactive postural control, anticipatory postural control, dynamic stability, sensory integration and cognitive influences. It is only logical that the majority of the components are to be addressed in a multicomponent exercise programme. In a recent review, Okubo et al. [15] reported that exercise programmes that contain stepping as a key component improved reaction time, gait speed, balance function and significantly reduced (as compared to the other programmes) the number of falls of older adults. Stepping is a fundamental movement component of walking over level ground, walking up and down stairs and is a part of balance reactions that are generated from perturbations from the environment and from the self-initiated movements [16]. Stepping on the level ground and stepping on the elevated surface such as stair climbing or aerobic step training during exercises, is a complex balance activity. It requires shifting the weight from one to the other leg and stabilisation on the loaded leg, dynamic stability during weight shifts, height and depth perception, eye leg coordination for height and depth of stairs negotiation, sufficient concentric muscle power to lift the weight of the body during ascending and sufficient eccentric muscle power to lower the body during descending. Thus stepping includes eight of the identified nine balance components (it does not address directly stability limits). The degree of stepping components as a part of the balance specific programmes has not been established. Therefore, we evaluated the number of steps and its intensity during the balance specific exercise programme for community-dwelling older adults. The purpose of the present work was to evaluate feasibility of step counts during exercise programme and to evaluate the number of steps and the intensity of stepping of the multicomponent balance specific exercise programme.

MATERIAL AND METHODS

PARTICIPANTS

Thirty-one older adults participated in the study. The group consisted of 29 females and 2 males; one person was excluded from analysis (younger than 60 years). Thirty participants remained for the final analysis. The sample characteristics are presented in Table 1. The balance function of the participants was assessed with: the Timed up and go test [17], the Stepping test [18] and the Functional reach test [19]. Falls were reported during the initial descriptive data gathering. These results are also presented in Table 1. Prior to enrolment, participants were informed of the purpose and procedures of the study and signed an informed consent. The study was approved by the Slovenian Medical Ethical Committee.

Table 1 Descriptive characteristics of the sample (N = 30)

	Average (SD)	Range
Age (years)	69.7 ± 6.2	60 – 80
Height (cm)	163.3 ± 7.5	150 – 180
Weight (kg)	67 ± 12	52 – 90
BMI	25.9 ± 4.1	33.6 – 19.9
Timed up and go test (seconds)	7.5 ±1	5.1 – 9.5
Stepping test (steps)	16.6 ± 2.8	9.5 – 23
Functional reach (centimetres)	31.7 ± 6.7	14 – 43
Number of reported falls in past 6 months	1	/

INSTRUMENTATION

The number of steps was acquired with StepWatch™ (Cyma, Mountlake Terrace, WA, USA) pedometers. The StepWatch 3.1 software was used for data processing. The StepWatch™ system is valid and reliable for the group of older adults (ICC = 0.84), and its accuracy was reported at 96% [20] and was found to be reliable at different walking speeds [21].

PROCEDURE

The measurements took place between November and December and included 11 consecutive training units. One StepWatch device was fixed above the ankle of the physiotherapist who was the exercise conductor. In each session three StepWatch devices were also worn by three randomly chosen participants; therefore, during 11 training units each participant wore the StepWatch at least once. Each unit of the exercise programme lasted for one hour. To address the majority of the balance components in one unit of the programme, the programme was divided into the three parts. The first part consisted of warming up of the upper body and upper extremities in a standing position with constant stepping followed by aerobic stepping. The second part consisted of mat activities. These two parts corresponds to approximately half of the unit time. The third part was circuit training with minimum of three stops followed by learning of dance choreography. The stepping component, volitional stepping as well as reactive stepping was part of the first and the third part of the programme. The programme was kept constant during the monitoring period.

Our operational definition for the multicomponent exercise was to address various components of balance (static stability, underlying motor systems, functional stability limits, verticality, reactive postural control, anticipatory postural control, dynamic stability, sensory integration and cognitive influences) and followed the system model [22]. The concept was described elsewhere [23]; however, since the description is not in the English language, the short description is presented here. The balance-specific exercise programme is organized as a multicomponent programme and all the above mentioned balance components were addressed with:

- exercises that enhance the musculoskeletal system – flexibility, muscle strength, etc.);
- exercises that facilitate the development of neuromuscular synergies (the centre of gravity (CoG) control, changing the CoG position in all directions to promote safe transitions between different positions, shifting the CoG to the limits of the supporting surface, unexpected perturbations and reaction time);
- exercises that facilitate the development of sensory strategies (alteration of sensory flow from the supporting surface and visual and vestibular systems, rotation of the head and body around the vertical axis to elicit the vestibulo-ocular response, standing and walking on a hard and soft surface to evoke anticipatory postural adjustments and reaction stepping);
- exercises that increase the cognitive load (attention and dual tasking, simultaneous performance of a motor and cognitive task or two motor tasks);
- exercises that facilitate stability during volitional movements (anticipatory postural adjustments, core and extremities stability);
- exercises that emphasise adaptation to environmental constraints (obstacle avoidance and walking over obstacles or on a narrow path which requires more hip control and enhances hip strategy training).

Statistical analysis

The Statistical Package for Social Sciences (SPSS 24, SPSS Inc., Chicago, IL USA) package was used for descriptive statistics. To normalize the number of steps in the first part of the exercise units, the step count of the physiotherapist served as a reference value for calculation of the ratio of steps between the therapist who conducted the exercise unit and the three participants. This ratio expressed as percentage was then further analysed and is presented in the results section.

Results

In the eleven consecutive exercise sessions, the average recorded number of steps per unit by participants was 1100.2 ±215.4 and the average number of steps performed by the unit conductor (physiotherapist) was 1247.5 ±139.3. The further analysis is presented for the three consecutive parts of the balance specific exercise programme (Table 2). The highest step count was in the first part 665.7 ±192.7, followed by circuit training 374.9 ±112.9. As expected, the lowest number of steps was recorded during mat activities (Table 2). In the first part, the ratio between the therapist who conducted the training and the participants was 0.96 ±0.3.

The intensity of stepping through the whole unit was divided into three levels (as defined by StepWatch software): the low level (less than 15 steps per minute) lasted 9.9 ±3.9 % of the unit time, moderate (between 16–40 steps per minute) lasted 45.9 ±14.2 % of unit time, and a high level of activity (more than 40 steps per minute) lasted 43.6 ±16.6% of unit time.

Table 2 Step counts, minutes per unit and percentage of steps for the three parts of balance specific exercise programme (N = 30)

	First part (warming up and aerobic stepping)	Second part (mat activities)	Third part (circuit training and dance)
Number of steps	665.7 ±192.7	59.6 ±19.7	374.9 ±112.9
Minutes of the unit	14.3 ±3.2	20 ±4.9	25 ±5.1
Percentage steps of the whole training unit	59.8 ±9.0	5.6 ±2.6	34.6 ±9.8

DISCUSSION

The intensity of balance training is difficult to assess properly. In the literature, there is no reported approach for the measurement of the intensity of balance training [24]. Recent recommendation is based on the meta-analysis [24]; however, the authors were not able to establish the volume of a single unit of balance training. For balance programmes where steps are an integral part, step counts could be used to monitor the intensity as well as the volume and progression. Therefore, the purpose of the present work was to evaluate the specific volume and intensity of steps during the multicomponent balance specific exercise programme and to evaluate the feasibility of steps monitoring with ankle placed pedometers. Counting steps during an exercise programme was feasible. The stepping monitors (pedometers) were placed above the participant's ankles; there were no interference of the pedometers with the participants' performance. Based on the previous reliability studies [20], we can conclude that pedometers applied in the ankle region provide a reliable measurement of the volume and intensity during the exercise period. This placement has been reported to be superior and more accurate compared to waist [25] or wrist placement [26]. The results showed that participants performed on average 1100 steps per one unit indicating that this type of exercise programme requires a high dose of stepping.

This number of steps in one exercise unit accounts for 16 percent of daily step counts if the reported average value by Bohannon [27] is considered. Most of the studies reported daily step of persons older than 65 to be on average above 6500 steps per day [27]. He reported that an average number of steps of women over the age of 65 was 6855 ±1674. This estimate corresponds to the recommended daily step count of 7000–8000 for healthy older adults [28]. The intensity, as defined by StepWatch software, of the stepping in the described programme was high for 43.6% of the unit time in the first part of the programme, moderate for 45.9% of the unit time during circuit training, and while only 9.9 percent of the whole unit time (mat activities) was in a low intensity range. The recorded 43.6% of unit time was in a high level of activity, which corresponds to 20–30 minutes and reaches the recommended daily time of vigorous activity [29]. However, the intensity of the balance specific programme in its most intensive first part did not reach the cadence of 100 steps per minute and the recommendation of 3000 steps in 30 minutes or 1000 steps per 10 minutes [30] was not followed in this programme. The intensity of balance programmes is often low to moderate [5] and still effective for the purpose. For interventions which challenge balance, movements of the centre of mass, narrowing of the base of support and minimising upper limb support need to be facilitated. Additionally we need to point out that the purpose of the exercise programme is primarily balance and not maintenance or increase in aerobic capacity.

On average, the ratio of step counts of the conductor and participants of the given programme unit was 0.96 indicating that the intensity of the first part of the programme was achievable for most of the participants. The volume and the dose could be monitored by the conductor and can be changed according to the progression of the programme (group).

The rationale for monitoring of the steps in a balance specific programme is based on a fact that voluntary stepping interventions reduce falls among older adults by approximately 50% [15], while other types of balance enhancement programmes report up to 39% decrease in the incidence of falls [5]. In our balance specific exercise programme, stepping was found to be an important component and since stepping was found to be the most efficient exercise strategy for fall prevention in the elderly [15], it is reasonable to suggest that our balance specific exercise programme has the potential to be efficient for fall prevention of the community-dwelling older adults. The superiority of the stepping component for fall prevention [15] indicates that balance-challenging programmes with pronounced stepping component should be recommended for fall prevention.

Additional argument for the use of step counts to measure progression is the fact that groups of functionally fit elderly can reach the ceiling of the functional balance measures. For instance, the balance function of the participants in our study was very high, as demonstrated by the Timed Up and Go, Functional reach and Stepping tests. According to the normative data for the elderly persons, their balance was in the range of 60 years old adults; the normative value for the Timed Up and Go test is 8 ±2s [31] and for the Step test – 18.7 steps for persons younger than 60 years [32]. Therefore, a type of measure with low ceiling effect is required for monitoring the progression of the fit participants in balance programmes. The use of pedometers offers a simple and reliable means of monitoring the volume and intensity of exercise programs, given the steps are their integral part.

The main limitation of the study is a convenient sample of participants and the low number of pedometers as described in the present work can be considered as a possible source of variability. In future studies each participant should wear an ankle fixed pedometer in several consecutive exercise units to ensure reliability of the acquired data.

CONCLUSIONS

Our study showed that the step count was an easy-to-perform method of monitoring the level of activity and the volume of a balance specific exercise programme. Besides, the use of pedometers also allows monitoring the intensity of the programme (i.e. step counts, cadence, and the ratio between high and moderate parts of the programme) as well as provides information for monitoring the progression of the programme or an individual. The concept of multicomponent balance specific exercise programme can be organised in a way to reach a high stepping amount and thus a potential not only for balance improvement that has been previously established in a group of nursing home residents [33] and community dwelling older adults [12], but it has also potential for fall prevention. Namely, only one of the thirty participants reported a fall in the period of 6 months.

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