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DETERMINING FUNCTIONAL ABILITIES OF LOWER EXTREMITIES IN ELDERLY AS A PREDICTOR OF FALLS IN RELATION TO THE EXPECTED NORMS

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SUMMARY

Ability to walk is one of the main motor activities that allow a man to independently function in a social setting. The speed at which a person walks is considered the „sixth sign of vitality" and is a reliable and sensitive discriminating factor in the prediction of falls in the elderly; it helps to predict the health status of an individual and possible hospitalization and mortality.

Determining the functional abilities of the lower extremities in the elderly as a predictor of falls in relation to the expected age and gender normative values.

In order to assess the functional abilities of the lower extremities "Time Up and Go Test–TUGT" was used. The sample included a total of 44 examinees, 24 were male and 20 female examinees. The examinees had between 75-85 years (77,26, SD=2,646). The research was conducted in June 2014 in a residential care home „Bežanijska kosa", in Belgrade, Serbia.

The research showed that the average achievement of the examinees on the TUG test was 17,77 seconds (SD=4,972). The examinees of the first age group had the achievement respectively 15,96 and 17,04, while respondents of older age group had the average achievements respectively 19,60 and 19,48 seconds. A significant effect of the age factor was found, but no significant effect of the gender factors. Compared to the normative values, all differences were statistically significant, which means that the examinees had a higher achievement in all the parameters compared to the expected ones.

According to the results, our examinees belong to the category with a high risk of falls.

Key words: elderly, walking, falls, TUG test

INTRODUCTION

Walking represents a basic motor activity, which significantly affects persons` biological-existential functioning. The ability of independent walking allows a person to discover the world around him, to develop his motor-cognitive capacities and achieve social interaction with other people. In the nature of man there is a need to satisfy various life needs and functions, which are largely achieved through movement. In literature there are different definitions of walking, and one of them is that walking is a rhythmical movement of legs with the goal of providing support and drive for the purpose of locomotion, that it is primarily an automatic process, whose change is under voluntary control (Whittle, 2002).

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Development of walking is a very dynamic and complex process that begins at birth, goes through several stages, so that the child could walk alone around the end of the sensorimotor period, however, this development continues up to the period of early childhood (Piaget, 1978). The cycle of walking is the period that begins with contact of heel of one leg to the re-contact of the heel of the same leg on the surface, so the cycle itself consists of two steps, that is, it is equal to a two-step (Burnifield, 2006). Walking can be divided into two phases, support phase, when one foot is in contact with the surface, and the swing phase, when the foot is not touching the surface. Walking, that is, controlled movement of the center of gravity in space, is a complex activity, of both external and internal forces (Mejovšek, 1997), and it requires functional and the physiological preservation of different systems of the organism, and the two basic components are: postural balance and muscle force of the lower extremities.

Balance is the ability to retain or maintain the body in a stable position, at rest, and it may be static or in motion, i.e. dynamic balance (Shumway-Cook, 2001). The system of postural balance is the position of unstable balance, because the short and narrow surface of the support is limited by the outer edges of the feet, by the line connecting the tips of both big toes and links the heel prints at the back (Stošljević et al., 1997). Therefore, this system is a complex mechanism that requires the joint action of the musculoskeletal and nervous system such as: visual, vestibular, and somatosensory systems (Adamović & Stošljević, 2013). The interaction of these systems enables: the maintenance of the normal position of the – head in space, head in relation to the body, and the extremities in relation to the body; supporting reactions (resistance); and maintaining a balance in relation to the movement of the center of gravity of the body (Stošljević et al., 1998).

Old age can be defined as the universal process of devolution, although it is not a disease, *de facto* it represents the age of diseases whose final result is the death of an individual. Paradoxical is the fact that medicine as a science on the one hand led to longer life expectancy, while, as the result of a longer life, man began to suffer from many diseases (heart attack and stroke, limitations in motor functioning, dementia). Old age in relation to the biological age of man can be divided into several stages. The beginning of old age can be restricted to the age group of 65-75 years, middle old age of 75-85 years, and advanced old age above 85 years (Stošljević & Adamović, 2013).

As a person gets older, the capacity of his muscle-skeletal systems becomes weaker, there is a loss of muscle mass and strength, which directly compromises walking and balance (Vale, 2009). These are the usual changes that occur in the elderly people, i.e. Problems with balance and walking occur due to dysfunction of the locomotors' apparatus and sensory systems (Christofoletti, 2008). In this sense, the difficulty in maintaining balance in the elderly, is the result of the aging process, which involves several different structures of the body, and as a result, may lead to the fall of a person (Alves Júnior, 2008).

Besides balance, another important component for independent walking is the muscle strength of lower extremities, which in all ages, including older people, has a very important role in the independent movement, such as, for example, climbing stairs or rising from a chair (Lord, 2002), and is also closely linked with balance (Frandin, 1995). It should be noted that with age in the elderly people there is a gradual decline in

motor plan, especially the leg muscles become weaker, as well as the ability to maintain balance, which can greatly limit independent walking and contribute to the occurrence of falls (Kimura, 2000).

Falls are the leading causes of injuries in people aged over 65 (Hornbrook, 1994), about 30% of the population experiences falls each year (Hausdorff, 2001), while that number increases as the age increases (Peeters, 2010). Falls in the elderly leads to serious physical consequences that in many cases can result in institutionalization and hospitalization and even death, and about 10% of the elderly who fall have severe injuries, while about 5% experience a fracture (Stalenhoef, 2002). Also, there are psychological problems that are usually associated with fear of falling again, loss of self-esteem, social isolation, avoidance of activities, which in general lead to functional limitations in daily activities (van Dijk, 2008). In Serbia, according to the Institute of Public Health in 2012, 17,5% of the population was older than 65, which classifies it as a country whose population is on the verge of demographic aging (ZSGRS, 2012). Statistics show the extreme importance of falls in the pathology of the elderly and the annual prevalence in people older than 65 is 28%. Injuries are the sixth cause of death in people older than 65 and 70% of injuries occur due to falls (Kulić, 2013).

In the relevant scientific literature there are many different definitions of a fall. According to Sehested (1977), a fall is a sudden, unexpected change of position, during which static and mechanical mechanisms are not able to fulfill their function, and willing mechanisms and reflexes that are responsible for correcting the balance are not adequate. According to Tinetti (1997) a fall is a sudden, unintentional change in position which causes an individual to land on a lower level, on an object, on the floor, or on the ground, and that fall does not occur as a result of paralysis, seizure, epilepsy, or severe impact of an external force.

The main characteristic of aging is the progressive deterioration of man's functionality and appearance of various pathological conditions that directly or indirectly affect the independent walking and the occurrence of falls. Due to aging all anatomical and functional structures of the eye become weaker – visual acuity, the ability of accommodation to light and darkness – and because of this the person is not able to estimate the distance in some situations and this leads to falls (Jovanović, 2007). As for neurological diseases which particularly compromise walking, we should mention Parkinson (Perez, 2012) and Alzheimer's disease (Aarsland, 2010), and various forms of polyneuropathy (Pasnoor, 2013). The peculiarities of the Third Age are also cardio-vascular diseases, e.g. arterial hypotension, which can, due to a sudden drop in blood pressure, lead to syncope and subsequent fall (Furuang, 2011). A person older than 65 years in average takes between 3-12 medicines, and it is not necessary to emphasize what kind of impact they can have on walking when taken at the same time, thus significantly increasing the risk of falls (Sumrak, 2000). Research shows that 30% of people over the age of 65 have vertigo (Colledge, 1994), which is largely considered a risk factor for falls (Pluijm, 2006). As for the change of the locomotor apparatus, we should note sarcopenia, a condition characterized by loss of skeletal muscle mass and strength (Cruz-Jentoft, 2010), that represents an increased risk of death, because the affected population often experiences accidents, resulting in various forms of disabilities (Bautmans, 2009). Last but equally important conditions in old age are

osteoarthritis of hips and knees (Pagès-Castellà, 2013), as well as osteoporosis, where due to problems with balance in combination with reduced bone density, the effect of the minimum force leads to falls, and the most common result is fracture of the femoral neck, which has serious consequences on old people and sometimes even has a fatal outcome (Hsu, 2014).

Postural instability, i.e. inability to maintain balance in the elderly is also a risk factor that contributes greatly to the appearance of falls (Kellogg, 1984). Kerber (1998), by using posturography, found a correlation between difficulty in maintaining balance and occurrence of accidental falls in the elderly, highlighting postural instability as a key factor that may explain the falls. The results obtained by Tuunainen (2011) indicate that the elderly, in order to maintain balance, use a very small surface of the ground as a support ($5cm^2$), and the different situations in which they can find themselves in their daily activities result in person going beyond its safe limits of support, which would result in a loss of balance, which can result in a fall.

A number of reliable, valid and discriminatory instruments for assessing balance, walking and the risk of falling, can be found in the literature, such as *the Timed Up and Go Test, Berg Balance Scale, Dynamic Gait Index and Modified Clinical Test for Sensory Interaction on Balance*. These tests allow a quick and easy measurement of walking capacity, so they are often used in practice. Next chapter will give a presentation of the research in which a variety of instruments were used as well as a test relevant to this study.

Research shows that measuring walking speed is a useful instrument that can have an important predictive factor for assessing the risk of falls. Harada (1995) points out that measuring the speed of walking can be used to determine the risk of falls, i.e. a person that walks slower than 34 meters per one minute, has a greater opportunity to experience a fall. Cesaria et al., (2005) in their research found that if an older person walks less than one meter per second, the person is considered to have an increased risk of physical accidents, as well as death. Studenski (2007) in his work came to the conclusion that the average walking slower than 60 cm/m represents a potential risk factor for hospitalization, as well as a reflection of weakness of general condition of the body and its functioning.

Timed Up and Go Test is used to assess mobility, i.e. balance and ability to walk, as well as for the evaluation of the risk of falling in the elderly (Podsiadło &Richardson, 1991). If elderly person needs more than 14 seconds to complete TUG test, than he falls into the category of those with a high risk for falls (Shumway-Cook, 2000). Also, in the literature we can see that it was used for people with cerebral paralysis (Andersson et al., 2003), multiple sclerosis (Cattaneo et al., 2006), older people with some disease (Shumway-Cook, 2000), and for people with spinal cord injury (Hubertus et al., 2005).

THE AIM OF THE RESEARCH

The main goal of this research is to determine the functional abilities of the lower extremities as a predictor of falls in the elderly compared to the expected age and gender values.

MATERIALS AND METHOD

Sample

The study included a total of 44 examinees, 24 examinees were male (N=24) and 20 examinees were female (N=20), aged 75-85 (M=77,26, SD=2,646). There was a statistically insignificant $\chi 2$ test for the number of men and women ($\chi 2$ (1) =0,364, p>0,05), that indicates that there was no statistically significant difference in the number of men and women in the sample. All examinees were users of Residential Care Home „Bezanijska kosa." The study was conducted during April 2014. All examines who participated in the research gave their consent and were informed about the details of its procedures.

Criteria for the inclusion in the study was that all examinees are able to move, that they do not use aids when walking, and that they can walk at least 30 meters independently. People who had a hip fracture, cardiac surgical intervention in the past year, or a disease of neuromuscular or musculoskeletal system, were not included in the study. All information related to their current health status were taken from the documentation, as well as through the discussion with the attending physician and with the examinee.

Instruments

The Timed Up and Go test – TUG-Test Basic instructions given to the examinee are that at the examiners command „*go*" they have to, from a sitting position (back straight) on a chair (45 cm high, which is considered a standard-size for this test) without handles, stand up and normally walk three meters to the adhesive tape on the floor, turn around and come back again and sit in the chair.Stopwatch is used to measure the time (in seconds) that a person needs to perform the test from the moment of giving the command until the return to the original sitting position. Examinees perform the test in the shoes they normally wear on a daily basis, and it is also recorded if a person uses some type of aid. The test is first demonstrated to each examinee and they are allowed one trial attempt. The results obtained are then compared to the normative value that are expected for the given age and gender of the examinees.

Data analysis

Data were analyzed using the t-test for independent samples in order to examine the influence of gender and age on the achievement on the TUG test. In addition, one of the main objectives of this study involved the comparison of examinees' results on the TUG test with the normative values established in a previous study by Steffen et al., (2002). The results of the examinees were compared to norms – defined by age and gender criteria using a simple t-test, and Table 1 provides an overview of the expected reference norms for the results on the TUG test in relation to gender and age.

Table 1 Normative values of TUG test in relation to gender and age for the elderly examinees from the general population (resource: Steffan et al., 2002)

Age	Gender	N	M	SD	95% CI
60-69	M	15	8	2	7-9
	F	22	8	2	7-9
70-79	M	14	9	3	7-11
	F	22	9	2	8-10
80-89	M	8	10	1	9-11
	F	15	11	3	9-12

RESULTS

The average result of the examinees on the TUGT was 17,77 seconds (SD = 4,971), as shown in Table 2.

Table 2 Descriptive measures of the results of the examinees on the TUG test

	N	Range	Min	Max	M	SEm	SD	Variance	Sk	Ske	KU	Kue
TUG	44	26,75	10,39	37,14	17,77	0,749	4,97194	24,72	1,335	0,357	3,882	0,702

N–Number of respondents, Min–Minimal value, Max–Maximal value, M–Mean, SEm–Standard error of mean, SD–standard deviation, V–Variance, Sk-Skewness, Ske–Standard error for skewness, KU-Kurtozis, KUe–standard error for kurtozis.

Average result for men was 17,77 (SD=5,622), while the average result for women was 17,77 (SD=4,20). Using the t-test for independent samples showed no statistically significant differences on the TUG test in relation to gender (t-test (42)=–0,005, p=0,996). This result indicates that this study showed no gender differences in the results on the TUG test, which further suggests that gender is not a significant factor in the speed of performing the TUG test, in this sample group.

In order to examine whether age can be considered a significant factor in terms of the results on the TUG test, the t-test for independent samples was used in which age was treated as a factor, while the dependent variable was the result on the TUG test measured in seconds. The examinees were divided into two age groups: 70-79 (N=26) and 80-89 (N=18). The results showed significant differences in the results of the examinees on the TUG test in relation to age. It was found that younger examinees needed less time in taking this test (M=16,54) compared to the examinees from older age group (M=19,56). Examinees from the younger group had better results on the TUG test (M=16,53; SD=3,739) compared to the examinees of the older group (M=19,56; SD=6,020). The results are presented in Table 3.

Table 3 Statistical significance of differences in the results on the TUG test between examinees of different age groups

	Age	N	M	SD	SEm	t-test	df	Sig
TUG	70-79	26	16,54	3,.74	0,733	-2,056	42	0,046
	80-89	18	19,56	6,02	1,419			

N-Number of respondents; M–Mean; SD–standard deviation; SEm–standard error of mean; Sig–statistical significance.

In order to examine whether the results of the examinees differ from the normative values established in previous studies (Steffen et al., 2002) the t-test analysis was used. Criterion was determined separately for men and women of certain age groups. The results are presented in Table 4.

Table 4 Comparison of the results of the examinees on the TUG test to the normative values for age and gender of the examinees using t-test (normative values were taken from the study by Steffen et al., 2002)

Age	Gender	Norms	N	M	SD	SEm	t-test	df	95% CI	95% Ci
70-79	M	9	12	15,94	3,541	1,022	6.792***	11	4,693	9,192
	F	9	14	17,05	3,96	1,058	7.602***	13	5,759	10,332
80-89	M	10	12	19,6	6,803	1,964	4.887***	11	5,275	13,92
	F	11	6	19,49	4,626	1,889	4.492**	5	3,63	13,34

Age-Age range, Gender–Gender of respondents, Norms–Normative values, N–number of respondents; M–Mean; SD–standard deviation; SEm–standard error of mean; Sig–statistical significance for mean difference; Dm–mean difference; 95% CI–95% confidence interval

The results presented in Table 4 indicate that the results of the examinees in this study are far beyond the expected normative values in relation to gender and age criteria, which is indicated by the size of the simple t-test established while comparing the results of the TUG test of the examinees with the appropriate norms. Specifically, when compared to the expected 9 seconds needed for the completion of the TUG test, male examinees, aged 70-79, competed the test for 15,94s, while women of the same age group had even lower achievements, with an average time of 17,05s. Age norms for examinees aged 80-89 amounted to 10s for men and 11s for women. The examinees of these age groups, both men and women have lower achievements (longer time of completion of the test) on the TUG test. The result for men was 19,60s and 19,49s for women. No statistically significant differences were found in relation to gender within the same age groups, t-test (24)=-,743, p>,05, for examinees aged 70-79, t-test (16)=0,036, p>,05, for those aged 80-89.

DISCUSSION

The aim of this paper is to examine the assessment of the risk of falling in 44 examinees, aged about 75-85 from the general population, using the TUG test. The aim of this study was to determine the average values of the results on the TUG test in

examinees of older population in Serbia, as well as comparison with normative values established in the work of Steffan et al., (2002). Analysis of the results obtained in this study showed the longer average time (17,77 seconds) required for the completion of the TUG test compared to the time required for the completion of the same test presented in previous studies (Bohannon & Schaubert, 2005; Bischoff et al., 2003; Campbell et al., 2003; Giladi et al., 2005; Shumway-Cook et al., 2000). Our results were correlated with the results of the previous studies that also showed the longer time required to perform the TUG test in the elderly examinees from the general population in relation to the expected age norms (Lin et al., 2004; Steffen et al., 2002). The results of the research indicate that all the examinees within the age groups, belong to the group with a high risk of falls, according to the results which showed that the average achievement higher than 14 seconds on the TUG test is a limit value for high risk of falls. The average achievements of the examinees in the research, longer than the average achievements reported in previous studies on old examinees who were functionally independent, confirm specificity of the used sample, as old examinees who are able to move and are of good health. These results resemble the results of the research of Podsialdlo and Richardson (1991), and Hughes et al., (1998) who also used the same procedure of walking 3metres, they did not include examinees with disabilities, and they found that the average achievement was higher than 10s. Newton (2001), by applying the TUG test on a sample of 204 examinees in the U.S. population, found the highest average time on the TUG test as well as the largest range of results, which amounted to 15,5 ± 7,7 for the age group of 70-79 and 26,8 ± 14,6, for the age category 80-89. In relation to the achievements showed in this paper, our examinees had far better achievements (17, 77 seconds). Lin et al., (2004) within their research on a sample of 1200 individuals (709 males and 491 females) aged 65 (average age 73,4) examined the validity and reliability of four different tests for the assessment of physical abilities, by using also, among others, TUG the test. The results obtained show that the examinees needed, in average, 15,2 seconds for the completion of the command while in our study the examinees needed, in average, more time to perform the task, which was 17,77 seconds.

We should mention the study by Steffen et al., (2002), who, on a sample of 96 examinees (37 males and 59 females), aged 60-89, evaluated the mobility by using four clinical tests (including the TUG test), in order to provide the normative values in relation to age and gender. In their paper the results which indicate age differences in the achievements on the TUG test were determined, in favor of younger examinees. This result was replicated in our study. This shows the need to use different age norms, for examinees of both genders, when using the tests for diagnostic purposes, for assessing the risk of falls. It should be noted that the survey of Bogle-Thorbahn and Newton (1996), applied to 66 examinees using the *Berg Balance Scale (BBS)*, which also, as in our study, lived in a residential care home, showed no statistically significant differences in the examinees according to their age. It may be that the difference in the results between our research and theirs is contained in the application of different tests. While in our study the TUG test was used, Bogle-Thorbahn and Newton (1996) used the BBS scale for assessing the risk of falls in individuals from the general population.

It should be added that in contrast to studies which established the influence of the gender factor on the achievements on the TUG test (Steffen et al., 2002), in this study

no difference was found in the average achievement between men and women. On the other hand, unlike the research of Steffen et al., (2002) in which the sample consisted of examinees who have lived in a community, independently, the examinees in this study have been living in a residential care home.

CONCLUSION

Independent and safe movement represents an important part of doing everyday activities and the participation of the individual in social activities (WHO, 2001), therefore it is logical that difficulties with walking, as well as incidence of falls, can lead to limitations in activities mentioned above. The purpose of this study is the need to evaluate the speed with which elderly people walk and compare it to normative age values (are they within the range expected, below or above the average, or in other words are they at higher risk of fall). For these reasons the study is focused on testing normative value results of elderly people from the general population, taken from a home for the elderly, aged 70-89 and using the TUG test, which, according to results of prior studies, is considered the best diagnostic instrument for evaluating the risk of fall. The study has found the subjects recorded results longer than the average expected normative values (17,7s). These results are an extension of prior studies which also found that the time taken to complete the TUG test is over 10 seconds, which according to the results is a lower category of risk of fall. Moreover, our study subjects, among this group of studies, are within the group with high risk of fall, because their average result on the TUG test is above even 14 seconds, that being considered the borderline for the group with high risk of fall.

Moreover, the study found age affected the results of the subjects on the test, while gender was not found to affect the results for the whole study group or within age groups. Therefore, gender was found to be a significant predictor of results on the TUG test. Therefore, based on the results of this study it is possible to recommend further measures of prevention, diagnostics, as well as rehabilitation of elderly people. Measures of prevention are mainly related to taking certain steps, in order to prevent falls, and they are related to built environment modifications in the surroundings (handrails, adequate lighting, door access, stairs), as well as forming special physical exercise programs and activities for elderly people, and also the economic consequences for the budget are not negligible because the process of rehabilitation is long and is a considerable burden on the healthcare system. These measures and activities are aimed at healthy, as well as frail elderly individual, family members, the narrower and broader social community, as well as the community overall. However, measures of prevention and creating adequate physical programs should be the subject of further studies which should contribute to improving the general physical health of the geriatric population as well as their quality of life.

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