Associations of total amount and patterns of objectively measured sedentary behavior with performance-based physical function

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**ABSTRACT**

Although greater sedentary time has been found to be associated with negative health impacts, little is known whether the specific pattern of sedentary behavior (i.e., sedentary bouts, breaks and durations) is associated with physical function among older adults. The present study examined the associations between objectively measured sedentary behavior and physical function among older Japanese adults. A total of 174 male and 107 female community-dwelling older Japanese adults aged 65–84 years (mean age: 74.5 ± 5.2 years) were recruited. Sedentary behavior and physical activity were assessed using a triaxial accelerometer. Physical function was measured through hand grip strength, eye-open one leg standing, 5-m walking, and timed up and go tests. Forced-entry multiple linear regression models adjusted for potential confounders were performed. After adjustment, total daily sedentary time and duration of prolonged sedentary bouts (both ≥ 30 min) were positively associated with time spent on the 5-m walking stage and timed up and go tests in older women; however, no significant associations were observed in older men or the whole sample. This paper highlights the importance of developing sedentary behavior change strategies for interventions aiming to improve mobility in older women. Further evidence from a prospective study is required to establish directions of causality between sedentary behavior and mobility.

1. Introduction

Japan is one of the rapid aging societies where 26.7% of its population was aged 65 or older in 2015. This proportion is predicted to be 38.8% by 2050 (Statistics Bureau, 2017). Older adults are at risk of declining physical function (Guralnik and Simonsick, 1993), which is related to higher risk of fall, functional limitations and disability, and mortality (Manton, 1988; Smee et al., 2012; Toraman and Yildirim, 2012). Despite many non-communicable diseases (Sedentary Behaviour Research, 2012), more sedentary time is associated with increased risk of metabolic syndrome, obesity, impaired mental health, and mortality among older adults (Balboa-Castillo et al., 2011; Bankoski et al., 2011; Inoue et al., 2012; Pavey et al., 2015). In addition, the key health consideration for older adults is maintaining a sufficient level of physical function to safely and independently perform regular daily activities (Department of Health, 2010). Sedentary behavior could be particularly important for older adults’ physical function because reduced energy expenditure, lack of skeletal muscular contractions and raised inflammatory markers through prolonged sedentary time could contribute to accelerated loss of muscle mass and strength (Gianoudis et al., 2015; Schaap et al., 2009). Therefore, to prevent or postpone declining physical function, a more in-depth understanding of the association...
Evidence has verified the negative relationships of self-reported and objectively measured sedentary behavior with aspects of physical performance such as muscle strength, mobility, and balance in older adults, independently of their moderate-to-vigorous physical activity (MVPA) (Hamer and Stamatakis, 2013; Manas et al., 2017; Seguin et al., 2012). However, most related studies have used self-reporting methods to assess sedentary behavior, which is a major limitation because older adults may have difficulty accurately recalling their total sedentary times or durations of specific sedentary behaviors (Van Cauwenberg et al., 2014). Although some studies have employed objective sedentary behavior measures, such studies are limited in several respects. First, most of these studies have been conducted in Western countries such as the United States, United Kingdom, Canada, and Portugal (Cooper et al., 2015; Fleig et al., 2016; Rosenberg et al., 2016; Santos et al., 2012). In comparison with Western countries, Japanese older adults may have different lifestyle patterns and gender role (Amagasa et al., 2017), which could possibly lead to different outcomes. Only one such study was conducted in Japan; however, this study was limited because of a small sample size of institutionalized older women (N = 19) (Ikezoe et al., 2013). Second, although older men and women were found to have different sedentary behavioral patterns and physical characteristics such as skeletal muscle mass (Bellettiere et al., 2015; Jankowski et al., 2008; Janssen et al., 2000; Matthews et al., 2008), few studies have examined the association between sedentary behavior and physical performance separately by gender. Finally, although two studies have reported that breaks in sedentary behavior were positively associated with physical performance in older adults (Davis et al., 2014; Sardinha et al., 2015), little is known regarding whether total and specific patterns of objectively measured sedentary behavior are associated with physical function. Given that prolonged and unbroken sedentary time has negative impacts on health (Hamilton et al., 2007; Dunstan et al., 2012), specific patterns of sedentary time can also be considered in terms of the number and duration of sedentary bouts. For the public health prevention practices, it is of value to further explore these modifiable factors related to physical function, such as total sedentary time, sedentary bouts (i.e., periods of uninterrupted sedentary time), breaks (i.e., nonsedentary bout between two sedentary bouts), and duration (i.e., the length of continuous sedentary time). Therefore, the present study examined the associations of total amount and patterns of objectively measured sedentary behavior with performance-based physical function among older Japanese men and women.

2. Materials and methods

2.1. Participants

Data from a cross-sectional survey conducted in 2013 were used in this study. A total of 3000 older Japanese adults aged 65–84 years and living in Matsudo City, Chiba Prefecture, Japan, were randomly selected from the Basic Resident Register according to gender and age bracket (65–69, 70–74, 75–79, and 80–84 years). This study involved two stages of data collection: a self-administered postal survey and on-site examinations.

In first stage, each potential respondent was sent a written consent form and questionnaire on their background that included questions on age, level of education, marital status, family income, and behavioral factors through the postal service. A total of 1250 older adults responded to this questionnaire by regular postal mail (response rate: 41.6%) and asked whether or not they were interested in taking part in additional examination. Those who showed their interest in additional examination (n = 951; response rate: 76.1%) were formally sent a letter requesting participation in the on-site examination via postal mail. However, 602 of those declined to participate; thus, 349 older adults who agreed to participate were ultimately enrolled in the present study.
sedentary time was calculated by summing the time spent engaged in
nurse, exercise trainers, physical therapists, and research sta-
number of sedentary breaks per sedentary hour were calculated.

Based on the previous studies (Sardinha et al., 2015; Caron et al.,
which is an indicator of physical function in older adults (Iusardi
Each participant was asked to walk 11 m without

5-m walking test: The 5-m walking test is a valid and reliable mea-
surement of gait speed (Salbach et al., 2001; Wilson et al., 2013),
which is an indicator of physical function in older adults (Iusardi
An accelerometer was used to measure the number of steps taken
during waking and sedentary periods. The accelerometer was
not worn during sleep, bathing, or any other activities that
would result in an absence of movement.

Descriptive statistics were calculated for all outcome measures
stratified by gender. An independent t-test and the chi-square test were
used for continuous and proportional variables, respectively.
Kolmogorov-Smirnov tests were used to assess if outcome variables
were normally distributed. Correlation coefficients were computed to
evaluate the relationship between wear time, total sedentary time,
number of sedentary bouts, duration of sedentary bouts, number of
sedentary breaks and MVPA. Accordingly, a minimum sample size of 85
participants was determined to detect an effect size of 0.15 in a model
with four predictors at 80% power. Forced-entry multiple linear re-
gression models adjusted for potential confounders and wear time of
the accelerometer were conducted to examine the associations of total
amount and patterns of objectively measured sedentary behavior (total
sedentary time, number of ≥30 min sedentary bouts, duration of ≥30 min
sedentary bouts, and number of sedentary breaks per sedentary hour)
with performance-based physical function (upper body
strength, balance, and mobility) for the whole sample and men and
women. All statistical analyses were performed using IBM SPSS 22.0
(SPSS Inc., IBM, Chicago, IL, USA). The level of significance was set at
p < 0.05.
A total of 281 participants aged 65–84 years (74.5 ± 5.2 years) comprising 174 men and 107 women were included in the present study. Table 1 summarizes the demographic and health variables for the entire sample stratified by gender. The chi-square test determined that men were more likely to be married, be educated to a higher level, be current smokers, and have alcohol-drinking habits than were women. The Kolmogorov–Smirnov tests showed that outcome variables were normally distributed (p < 0.05). Table 2 provides the descriptive data of total amount and patterns of objectively measured sedentary behavior, MVPA, and physical function.

Table 1
Characteristics and health status of the study participants.

| Variable              | Total (n = 281) | Males (n = 174) | Females (n = 107) | P  |
|-----------------------|-----------------|-----------------|-------------------|----|
| Age (years)           | 74.5 (5.2)      | 75.2 (5.4)      | 73.3 (4.8)        | 0.003 |
| BMI (kg/m²)           | 23.5 (3.2)      | 23.7 (3.0)      | 23.1 (3.4)        | 0.114 |
| Marital status (%)    |                 |                 |                   |     |
| Married               | 82.6            | 87.4            | 74.8              | 0.007 |
| Not married           | 17.4            | 12.6            | 25.2              |     |
| Living status (%)     |                 |                 |                   |     |
| Living with others    | 87.9            | 89.7            | 85.0              | 0.250 |
| Not living with others| 12.1            | 10.3            | 15.0              |     |
| Educational level (%) |                 |                 |                   | > 0.000 |
| Tertiary education    | 38.8            | 47.7            | 24.3              |     |
| Not tertiary education| 61.2            | 52.3            | 75.7              |     |
| Employment (%)        |                 |                 |                   |     |
| Yes                   | 27.0            | 29.9            | 22.4              | 0.172 |
| No                    | 73.0            | 70.1            | 77.6              |     |
| Life circumstance (%) |                 |                 |                   |     |
| Excellent             | 6.8             | 7.5             | 5.6               | 0.945 |
| Good                  | 54.1            | 53.4            | 55.1              |     |
| Poor                  | 36.3            | 36.2            | 36.4              |     |
| Disappointing         | 2.8             | 2.9             | 2.8               |     |
| Smoking (%)           |                 |                 |                   |     |
| Yes                   | 7.5             | 11.5            | 0.9               | < 0.000 |
| No                    | 92.5            | 88.5            | 99.1              |     |
| Alcohol drinking habit (%) |       |                 |                   |     |
| Yes                   | 54.1            | 69.5            | 29.0              | < 0.000 |
| No                    | 45.9            | 30.5            | 71.0              |     |
| Medical history (n)   | 1.3 (1.2)       | 1.3 (1.2)       | 1.4 (1.1)         | 0.424 |

Abbreviations: n, number; SD, standard deviation; BMI, body mass index. Tertiary education: university or college degree or higher; Alcohol drinking habit: current drinker. p < 0.05.

3. Results

A total of 281 participants aged 65–84 years (74.5 ± 5.2 years) comprising 174 men and 107 women were included in the present study. Table 1 summarizes the demographic and health variables for the entire sample stratified by gender. The chi-square test determined that men were more likely to be married, be educated to a higher level, be current smokers, and have alcohol-drinking habits than were women. The Kolmogorov–Smirnov tests showed that outcome variables were normally distributed (p < 0.05).

Table 2
Total amount and patterns of objective-measured sedentary behavior, MVPA, and physical function.

| Variables                          | Total (n = 281) | Males (n = 174) | Females (n = 107) | P  |
|------------------------------------|-----------------|-----------------|-------------------|----|
| Accelerometer variables            |                 |                 |                   |     |
| Wear time (min/day)                | 900.9 (86.4)    | 888.4 (97.0)    | 921.2 (60.9)      | 0.001 |
| Total sedentary time (min/day)     | 524.9 (111.7)   | 548.9 (115.4)   | 485.8 (93.5)      | < 0.000 |
| ≥30 min sedentary bouts (times/day)| 4.4 (1.9)       | 4.9 (1.9)       | 3.8 (1.7)         | < 0.000 |
| ≥30 min sedentary bout duration (min)| 233.0 (118.5) | 256.9 (120.5)  | 194.6 (104.9)    | < 0.000 |
| Sedentary breaks (times/sedentary hour)| 7.6 (2.9) | 7.1 (2.9) | 8.5 (2.6) | < 0.000 |
| MVPA (min/day)                     | 49.4 (32.5)     | 50.0 (35.5)     | 48.5 (27.2)       | 0.692 |
| Performance-based physical function|                 |                 |                   |     |
| Hand grip strength test (kg)       | 27.4 (8.4)      | 31.6 (7.1)      | 20.6 (5.1)        | < 0.000 |
| Eye-open one leg standing test (s) | 42.9 (21.6)     | 41.8 (21.5)     | 44.6 (21.8)       | 0.290 |
| 5-m walking test (s)               | 2.9 (0.5)       | 2.8 (0.5)       | 3.1 (0.6)         | 0.003 |
| Timed up & go test (s)             | 6.2 (1.2)       | 6.1 (1.2)       | 6.4 (1.3)         | 0.023 |

Abbreviations: n, number; SD, standard deviation; MVPA, moderate to vigorous physical activity. p < 0.05.
function stratified by sex, adjusting for the potential confounders and MVPA. Similar to the results for the whole sample, total amount and patterns of objectively measured sedentary behavior were not significantly associated with each physical function test in men. In women, total daily sedentary time was positively associated with time spent on the 5-m walking test (β: 0.247, 95% CI: 0.041, 0.607) and timed up and go test (β: 0.210, 95% CI: 0.003, 0.511). Furthermore, duration of prolonged sedentary bouts (≥30 min) was determined to be positively associated with time spent on the 5-m walking test (β: 0.249; 95% CI: 0.087, 0.534) and timed up and go test (β: 0.178; 95% CI: 0.003, 0.409).

4. Discussion

The present study was the first to examine the association of total amount and patterns of sedentary behavior with physical function in community-dwelling older Japanese adults by using objective measures including triaxial accelerometers and standardized physical fitness tests. These findings revealed that sedentary behavior is related to the performance of mobility (5-m walking and timed up and go tests) only in older women. Independent of potential confounders and MVPA, more total daily sedentary time and longer duration of prolonged sedentary bouts (≥30 min) were associated with lower levels of mobility performance only in older women. This could serve as a reference for policy makers and intervention designers when developing behavioral change strategies for mobility decline prevention.

This study demonstrated that total amount and patterns of sedentary behavior may exhibit stronger associations with the performance of mobility in older women than that in older men, which is inconsistent with the findings of a previous study conducted in the United States (Gennuso et al., 2016). This inconsistency could be explained by cultural differences between Western and Asian countries. It is possible that different lifestyle patterns and gender role between United States and Japan may lead to these reverse findings. Traditionally, Japanese women are responsible for most of the housework, and thus women are more likely to have lifestyle patterns involving less time engaged in sedentary behavior, resulting in longer periods of light-intensity physical activity and short-bout MVPA than men (Amagasa et al., 2017). Thus, longer total daily sedentary time and duration of prolonged sedentary bouts (≥30 min) might be more negatively related to mobility among older women than among older men in Japan. Furthermore, regarding the inverse association between sedentary behavior and mobility only observed in older women, the possible reason is that older total daily sedentary time and duration of prolonged sedentary bouts (≥30 min) are related to a lack of skeletal muscular contractions and raised inflammatory markers, which could contribute to accelerated loss of muscle mass and strength (Gianoudis et al., 2015; Schaap et al., 2009). Lower muscle mass was determined to be associated with reduced functionality of the lower limbs (Falsarella et al., 2014; Reid et al., 2008). Older women have lower amounts of skeletal muscle mass and muscle density than do age-matched men (Jankowski et al., 2008; Janssen et al., 2000; Bouchard et al., 2011; Goodpaster et al., 2001). Thus, the associations between sedentary behavior and mobility could be more profound in older women than in older men. However, the underlying mechanisms remain unclear. Future studies should focus on gender-specific associations between various patterns of sedentary behavior and physical function.

Several inconsistencies between previous findings and our results were noted. In contrast to the previous studies (Davis et al., 2014; Sardinha et al., 2015), the present study determined that breaking up sedentary time was not associated with superior physical performance in older adults. Moreover, although several studies have reported an inverse association between sedentary behavior and the performance of balance and muscular strength (Rosenberg et al., 2016; Ikezoe et al., 2013; Gennuso et al., 2016), no such significant associations were observed in the present study. Several possible reasons may explain these inconsistencies. First, participant characteristics may contribute to these inconsistencies; the older adults in the present study were younger than those in previous studies (Rosenberg et al., 2016), and also generally healthier, with superior performance in physical function (Ikezoe et al., 2013). Second, these inconsistencies may be attributable to the different objective measures of sedentary behavior; for example, in contrast to most related studies, which have used uniaxial accelerometers (Santos et al., 2012; Davis et al., 2014; Sardinha et al., 2015), the present study used a triaxial accelerometer to assess sedentary behavior, which may have yielded more accurate results among the older population than those obtained using an uniaxial accelerometer (Yamada et al., 2009).

Table 4

| Variables                          | Males (n = 174) | Females (n = 107) |
|-----------------------------------|----------------|------------------|
|                                   | β              | 95%CI P          | β              | 95%CI P          |
| Handgrip strength test            |                |                  |                |                  |
| Total sedentary time              | −0.082 (−0.225, 0.091) | 0.404 (−0.117 (−0.268, 0.096) | 0.350          |
| Number of ≥30 min sedentary bouts | 0.069 (−0.188, 0.305) | 0.639 (0.307)    | 0.860          |
| ≥30 min sedentary bout duration   | −0.027 (−0.158, 0.114) | 0.749 (−0.167 (−0.260, 0.028) | 0.114          |
| Sedentary breaks                  | −0.013 (−0.160, 0.138) | 0.886 (−0.100 (−0.158, 0.296) | 0.546          |
| Eye-open one leg standing test    | −0.073 (−0.252, 0.111) | 0.445 (0.001 (−0.285, 0.288) | 0.992          |
| Number of ≥30 min sedentary bouts | −0.099 (−0.382, 0.183) | 0.488 (−0.293 (−0.763, 0.115) | 0.146          |
| ≥30 min sedentary bout duration   | −0.103 (−0.256, 0.055) | 0.203 (−0.052 (−0.288, 0.169) | 0.609          |
| Sedentary breaks                  | 0.075 (−0.098, 0.244) | 0.399 (0.066 (−0.283, 0.432) | 0.680          |
| 5-m walking test                  | −0.081 (−0.239, 0.098) | 0.408 (0.247 (0.041, 0.607) | 0.025          |
| Number of ≥30 min sedentary bouts | 0.096 (−0.175, 0.349) | 0.513 (−0.064 (−0.515, 0.361) | 0.728          |
| ≥30 min sedentary bout duration   | −0.016 (−0.159, 0.130) | 0.844 (0.249 (0.087, 0.534) | 0.007          |
| Sedentary breaks                  | −0.022 (−0.178, 0.139) | 0.811 (−0.078 (−0.450, 0.256) | 0.587          |
| Timed up & go test                | −0.065 (−0.239, 0.116) | 0.495 (0.210 (0.003, 0.511) | 0.048          |
| Total sedentary time              | 0.153 (−0.126, 0.426) | 0.286 (−0.141 (−0.551, 0.235) | 0.427          |
| ≥30 min sedentary bout duration   | 0.001 (−0.152, 0.154) | 0.986 (0.178 (0.003, 0.409) | 0.047          |
| Sedentary breaks                  | 0.032 (−0.137, 0.198) | 0.718 (−0.020 (−0.341, 0.295) | 0.884          |

Abbreviations: β (95%CI), standardized regression coefficients and 95% confidence intervals. Adjusted by age, BMI, marital status, living status, educational level, employment, life circumstance, smoking, alcohol drinking habit, medical history, wearing time, and MVPA. Number of ≥30 min sedentary bouts and sedentary breaks are also adjusted for total sedentary time. P < 0.05.

Y. Liao et al. Preventive Medicine Reports 12 (2018) 128–134
Although this study adjusted for a comprehensive range of potential confounders based on community-dwelling older Japanese adults by using objective measurements, several limitations of the present study should be noted. First, the accelerometer data are limited by that they cannot capture postural information (i.e., sitting vs. standing still), which is possible to overestimate sedentary time. Second, this study adopted a cross-sectional design, and thus could not provide a direction of causality. Finally, convenient sampling, exclusion criteria of accelerometer data, self-selection bias (older adults who were relatively healthy could be more willing to participate in the present study) and the low response rate may compromise generalizability; therefore, the study sample may not likely represent the population of older Japanese adults.

In summary, the present study extended the knowledge that associations of total amount and patterns of objectively measured sedentary behavior with performance-based physical function were observed only in older women, which were drawn from the convenience sample. These findings highlight that more total daily sedentary time and longer duration of prolonged sedentary bouts (≥30 min) were associated with lower levels of mobility performance only in older women. This paper provides vital information for further studies to design sedentary behavior intervention strategies for older adults with similar lifestyles. Further studies using prospective design to confirm our results are still warranted.

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Disclosure statement

The authors declare no conflicts of interest.

References

Abizanda, P., Navarro, J.L., Garcia-Tomas, M.I., Lopez-Jimenez, E., Martinez-Sanchez, E., Paterna, G., 2012. Validity and usefulness of hand-held dynamometer for measuring muscle strength in community-dwelling older persons. Arch. Gerontol. Geriatr. 54 (1), 21–27.

Ainsworth, B.E., Haskell, W.L., Whitt, M.C., et al., 2000. Compendium of physical activities: an update of activity codes and MET intensities. Med. Sci. Sports Exerc. 32 (9 Suppl), S498–S504.

Amagasa, S., Fukushima, N., Kikuchi, H., Takamaya, T., Oka, K., Inoue, S., 2017. Light and sporadic physical activity overlooked by current guidelines makes older women more active than older men. Int. J. Behav. Nutr. Phys. Act. 14 (1), 59.

Balboa-Castillo, T., Leon-Munoz, L.M., Graciani, A., Rodriguez-Artalejo, F., Guallar-Castellar, P., 2011. Longitudinal association of physical activity and sedentary behavior during leisure time with health-related quality of life in community-dwelling older adults. Health Qual Life Outcomes 9, 47.

Bankoski, A., Harris, T.B., McClain, J.J., et al., 2011. Sedentary activity associated with metabolic syndrome independent of physical activity. Diabetes Care 34 (2), 497–503.

Belletiere, J., Carlson, J.A., Rosenberg, D., et al., 2015. Gender and age differences in hourly and daily patterns of sedentary time in older adults living in retirement communities. PLoS One 10 (8), e0136161.

Bouchard, D.R., Hervoux, M., Janssen, I., 2011. Association between muscle mass, leg strength, and fat mass with physical function in older adults: influence of age and sex. J. Aging Health 23 (2), 313–328.

Carson, V., Wong, S.L., Winkler, E., Healy, G.N., Coley, R.C., Tremblay, M.S., 2014. Patterns of sedentary time and cardiometabolic risk among Canadian adults. Prev. Med. 65, 23–27.

Chen, T., Narazaki, K., Honda, T., et al., 2015. Tri-axial accelerometer-determined daily physical activity and sedentary behavior of suburban community-dwelling older Japanese adults. J. Sports Sci. Med. 14 (3), 507–514.

Cooper, A.J., Simmons, R.K., Hui, D., et al., 2015. Physical activity, sedentary time and physical capability in early old age: British birth cohort study. PLoS One 10 (5), e0126465.
physical, and functional health among older adults in retirement communities. J. Gerontol. A Biol. Sci. Med. Sci. 71 (1), 78–83.

Salbach, N.M., Mayo, N.E., Higgins, J., Ahmed, S., Finch, L.E., Richards, C.L., 2001. Responsiveness and predictability of gait speed and other disability measures in acute stroke. Arch. Phys. Med. Rehabil. 82 (9), 1204–1212.

Santos, D.A., Silva, A.M., Baptista, F., et al., 2012. Sedentary behavior and physical activity are independently related to functional fitness in older adults. Exp. Gerontol. 47 (12), 908–912.

Sardinha, L.R., Santos, D.A., Silva, A.M., Baptista, F., Owen, N., 2015. Breaking up sedentary time is associated with physical function in older adults. J. Gerontol. A Biol. Sci. Med. Sci. 70 (1), 119–124.

Schaap, L.A., Pluijm, S.M., Deeg, D.J., et al., 2009. Higher inflammatory marker levels in older persons: associations with 5-year change in muscle mass and muscle strength. J. Gerontol. A Biol. Sci. Med. Sci. 64 (11), 1183–1189.

Sedentary Behaviour Research N., 2012. Letter to the editor: standardized use of the terms “sedentary” and “sedentary behaviours”. Appl. Physiol. Nutr. Metab. 37 (3), 540–542.

Seguin, R., Lamonte, M., Tinker, L., et al., 2012. Sedentary behavior and physical function decline in older women: findings from the Women’s Health Initiative. J. Aging Res. 2012, 271589.

Shimada, H., Tiedemann, A., Lord, S.R., et al., 2011. Physical factors underlying the association between lower walking performance and falls in older people: a structural equation model. Arch. Gerontol. Geriatr. 53 (2), 131–134.

Statistics Bureau, M. o. I. A. a. C, 2017. In: Communications, M. o. I. A. a (Ed.), Japan Statistical Yearbook 2017. Statistics Bureau, Tokyo Japan.

Taekema, D.G., Gusekloo, J., Maier, A.B., Westendorp, R.G., de Craen, A.J., 2010. Handgrip strength as a predictor of functional, psychological and social health. A prospective population-based study among the oldest old. Age Aging 39 (3), 331–337.

Toraman, A., Yildirim, N.U., 2010. The falling risk and physical fitness in older people. Arch. Gerontol. Geriatr. 51 (2), 222–226.

Tremblay, M.S., Aubert, S., Barnes, J.D., et al., 2017. Sedentary Behavior Research Network (SBRN) - terminology consensus project process and outcome. Int. J. Behav. Nutr. Phys. Act. 14 (1), 75.

Van Cauwenberg, J., Van Holle, V., De Bourdeaudhuij, I., Owen, N., Deforche, B., 2014. Older adults’ reporting of specific sedentary behaviors: validity and reliability. BMC Public Health 14, 734.

Wang, L., van Belle, G., Kukull, W.B., Larson, E.B., 2002. Predictors of functional change: a longitudinal study of nondemented people aged 65 and older. J. Am. Geriatr. Soc. 50 (9), 1525–1534.

Wilson, C.M., Kostuzka, S.R., Boura, J.A., 2013. Utilization of a 5-meter walk test in evaluating self-selected gait speed during preoperative screening of patients scheduled for cardiac surgery. Cardiopulm. Phys. Ther. J. 24 (3), 36–43.

Yamada, Y., Yokoyama, K., Norryuau, R., et al., 2009. Light-intensity activities are important for estimating physical activity energy expenditure using uniaxial and triaxial accelerometers. Eur. J. Appl. Physiol. 105 (1), 141–152.
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