Sedentarism in Recreational Marathon Runners

Nikolaidis, Pantelis T ; Knechtle, Beat

DOI: https://doi.org/10.2147/OAJSM.S444862

Originally published at:
Nikolaidis, Pantelis T; Knechtle, Beat (2023). Sedentarism in Recreational Marathon Runners. Open Access Journal of Sports Medicine, 14:103-109.
DOI: https://doi.org/10.2147/OAJSM.S444862

Open Access Journal of Sports Medicine

ORIGINAL RESEARCH

Sedentarism in Recreational Marathon Runners

Pantelis T Nikolaidis[1,2], Beat Knechtle[3,4]

[1]School of Health and Caring Sciences, University of West Attica, Egaleo, Greece; [2]Exercise Physiology Laboratory, Nikaia, Greece; [3]Institute of Primary Care, University of Zurich, Zurich, Switzerland; [4]Medbase St. Gallen am Vadianplatz, St. Gallen, Switzerland

Correspondence: Pantelis T Nikolaidis, School of Health and Caring Sciences, University of West Attica, Ag. Spyridonos, Egaleo, 12243, Greece, Tel +30 6977820298, Email pademil@hotmail.com

Aim: Although it has been previously observed that sedentary behavior (SB) was not related to training duration in marathon runners, little information existed about the relationship of SB with training, anthropometric and physiological characteristics in this population. This study aimed to investigate the prevalence of SB and its correlation with performance parameters (such as body fat percentage, maximal oxygen uptake and weekly training volume) as well as its variation by sex and day (ie, weekdays versus weekend) in recreational marathon runners.

Methods: A total of 151 finishers (women, n = 29; men, n = 122; age 43.1 (8.7) years, mean (standard deviation)) in the Athens marathon 2017 performed a series of anthropometric and physiological tests, and completed the Multi-context sitting time questionnaire.

Results: SB did not correlate with anthropometric and physiological characteristics and no difference in these characteristics was shown between low and high sedentary participants ($p > 0.05$). SB did not differ between women and men ($p > 0.05$), but differed between working and non-working days ($p < 0.05$).

Conclusion: In contrast to previous findings on the general population indicating an association of a high SB with a low cardiorespiratory and muscular fitness, our finding of no correlation between SB and physical fitness in marathon runners suggested that endurance exercise might offset the negative effects of SB.

Keywords: body fat, endurance exercise, long distance running, maximal oxygen uptake, moderate exercise intensity, physical inactivity

Introduction

Sedentary behavior (SB) has been a major health concern in the industrialized societies.[1,2] USA adults reported 9.5 h·day^{-1} of sedentary time mostly accumulated in the leisure (mainly watching television/videos or engaged in Internet/computer use) and work life domains.[2] SB (defined as sitting more than 4.5 h·day^{-1}) increased in the European Union from 49.3% in 2002 to 53.4% in 2017.[1] This behavior has been associated with an increased risk for several non-communicable diseases such as and add some examples[3] and health-related quality of life.[4] In agreement with the significance of this behavior, research on this topic has grown exponentially in the last decade.[5]

Paradoxically, despite the increase of the prevalence of SB during the last years, an increase of participation in endurance running events such as marathon was shown in studies on New York City Marathon 1970–2017,[6] Boston Marathon 1972–2017[7] and Berlin Marathon 1974–2019.[8] There was debate whether high levels of physical activity (PA; such in the case of recreational marathon runners) could fully counteract the harms of SB.[9] For instance, SB was associated with higher levels of adiposity, independent of moderate-to-vigorous PA; however, it was unclear whether this independent relationship still existed in highly trained athletes.[9]

Although an association of high SB with low cardiorespiratory and muscular fitness was observed in the general population,[10] little information existed about this relationship in marathon runners. What was known in marathon runners was that SB was not associated with training duration.[11] A review of 13 studies on SB and PA in athletes reported that, compared to the general population, athletes spent more time in SB and moderate-to-vigorous PA, and less time in light intensity PA.[12] Exel et al[13] studied SB and PA in master amateur runners and footballers and observed alarming times in

Received: 15 October 2023
Accepted: 21 December 2023
Published: 28 December 2023

bouts of 30-min of SB on weekdays. They highlighted the need to consider the excessive amounts of SB in master athletes that cannot be masquerade by adequate PA profiles.

In this context, the knowledge about the relationship of SB with anthropometric and physiological characteristics in marathon runners would provide practical information about the potential role of endurance exercise to offset the negative effects of SB. Therefore, the present study aimed to examine (a) the prevalence and trends of SB, ie, sex and age-related differences, differences between workdays and non-workdays; and (b) the relationship of SD with anthropometric, physiological and training characteristics in recreational marathon runners. We hypothesized that SB would be less prevalent in recreational marathon runners than in the general population, would differ between weekdays and weekends, and would correlate with worse performance characteristics.

Methods

Study Design and Participants

This is a cross-sectional study, where 151 finishers [women, n = 29; men, n = 122; age 43.1 (8.7) years, mean (standard deviation)] in the Athens marathon 2017 performed a series of anthropometric and physiological tests and completed a series of questionnaires including the Multi-context sitting time questionnaire (MSTQ).[11] Data from the participants' measurements have already been published;[14–16] however, MSTQ was not previously reported. All participants were recruited – mostly from the area of Athens – through public calls using social media and provided written informed consent before the testing session. Inclusion criteria were the successful participation in the Athens marathon in 2017 and the intention to compete in 2018. The study was conducted in accordance with the ethical principles derived from the Declaration of Helsinki about research in humans and was approved by the local review board (Exercise Physiology Laboratory, Nikaia, Greece; EPL 2017/3).

Protocols and Equipment

Considering the evaluation of SB, the parameters evaluated by MSTQ included sittitng while (a) working, (b) watching TV, (c) watching PC (non-working), (d) transportation and (e) socializing, in addition to sleep duration, separately for weekdays and weekends. Then, total SB was calculated as the sum of a, b, c, d and e. Whitfield et al[17] developed and tested the psychometric characteristics of the MSTQ. They supported that this tool has several improvements compared to previous tools and used it on marathon and half-marathon runners.[11] Recently, it was used on weight-loss maintainers,[18] college students,[19] minority group[20] and the general population.[21] The protocols and equipment of the measurements of the anthropometric and physiological characteristics can be found elsewhere in details.[14–16] Briefly, these measurements included the chronological age, height, weight, body mass index (BMI), body fat percentage using the sum of 10 skinfolds (BF), number of finished marathon races, marathon race record, training days and distance per week, maximal oxygen uptake (VO_2max) from a graded exercise test on a treadmill, sit-and-reach test (SAR), squat jump (SJ), countermovement jump (CMJ) and maximal power of a force velocity test on a cycle ergometer.

Statistical and Data Analysis

Two statistical packages, IBM SPSS v.29.0 (SPSS, Chicago, IL, USA) and GraphPad Prism v. 7.05 (GraphPad Software, San Diego, CA, USA), were used for statistical analyses. Descriptive statistics of SB were presented as medians and interquartile ranges (IQR).[11,17–21] A related-sample Wilcoxon Signed Rank test compared SB between weekday and weekend. An independent-sample Mann–Whitney *U*-test examined differences in SB between women and men. A cut-off of 9.0 h total SB was used to group participants into non-sedentary and sedentary, and the chi-square test examined their distribution by sex. Descriptive characteristics of the anthropometric and physiological characteristics were presented as means and standard deviations.[14–16] Spearman correlation coefficient (rho) examined the relationship of SB (non-parametric variable) with anthropometric and physiological characteristics (parametric variables) by sex. The magnitude of the correlations was evaluated as trivial ($rho < 0.10$), small ($0.10 \le rho < 0.30$), moderate ($0.30 \le rho < 0.50$), large ($0.50 \le rho < 0.70$), very large ($0.70 \le rho < 0.90$) and almost perfect ($rho \ge 0.90$).[22] The alpha level was 0.05.

Results

Total week SB was 9.0 h (6.8–10.9; median and IQR) in all participants, 8.0 h (6.9–11.2) in women and 9.1 (6.7–10.9) in men. A related-samples Wilcoxon Signed Rank test showed a difference between weekday and weekend in total SB ($Z = -7.906$, $p < 0.001$), sleep duration ($Z = 7.263$, $p < 0.001$), working ($Z = -8.607$, $p < 0.001$), watching TV ($Z = 6.047$, $p < 0.001$), transportation ($Z = -2.902$, $p = 0.004$) and socializing ($Z = 2.446$, $p = 0.014$), whereas no difference was found in watching PC ($Z = 1.942$, $p = 0.052$) (Table 1). According to independent-sample Mann–Whitney *U*-test, no difference was observed in SB parameters between women and men ($p \geq 0.150$).

In total, the number of non-sedentary (n = 75, 49.7%) was similar to that of sedentary participants (n = 76, 50.3%). Sedentary was 44.8% of women (n = 13) and 51.6% (n = 63) of men; however, no sedentary*sex association was observed (chi-square = 0.435, $p = 0.510$). No difference was observed between non-sedentary and sedentary participants, except in the cases of age and training days in women, where sedentary participants were younger and trained fewer days per week than their non-sedentary peers (Table 2). The correlation of SB with training, anthropometric and physiological characteristics can be seen in Table 3, where no correlation was shown except with age and jumping ability in women.

Discussion

The main findings of the present study were that (a) recreational marathon runners had high levels of SB, (b) their SB did not correlate with physiological, anthropometric, and training characteristics, and (c) marathon runners with different levels of SB did not differ for physiological, anthropometric and training characteristics. These findings did not confirm our research hypotheses of the detrimental role of SB on the performance characteristics of recreational marathon runners.

Table 1 Sedentary Behavior of Participants

Sedentary Behavior	Total (n=151)	Women (n=29)	Men (n=122)
Weekday			
Sleeping (h)	7.0 (6.0–7.5)	7.0 (6.0–8.0)	7.0 (6.0–7.0)
Sitting while working (h)	5.8 (2.0–8.0)	4.8 (1.6–7.8)	6.0 (2.0–8.0)
Sitting while watching TV (h)	1.0 (0.5–2.0)	1.0 (0–2.5)	1.0 (0.6–2.0)
Sitting while watching PC (non-working) (h)	1.0 (0–2.0)	1.0 (0.8–2.0)	1.0 (0–2.0)
Sitting during transportation (h)	1.0 (0.3–1.5)	1.0 (1.3–2.0)	1.0 (0.2–1.5)
Sitting while socializing (h)	0.5 (0–1.0)	1.0 (0–1.8)	0.5 (0–1.0)
Total SB (h)	10.0 (7.4–12.0)	9.0 (7.4–12.3)	10.0 (7.3–12.0)
Weekend			
Sleeping (h)	7.0 (7.0–8.0)*	7.0 (7.0–8.3)*	7.0 (7.0–8.0)*
Sitting while working (h)	1.5 (1.0–2.0)*	1.5 (1.0–2.0)*	2.0 (0.5–2.0)*
Sitting while watching TV (h)	2.0 (1.0–2.5)*	2.0 (0.3–2.5)	2.0 (1.0–3.0)*
Sitting while watching PC (non-working) (h)	1.0 (0.5–2.0)	1.0 (0–2.0)*	1.0 (0.5–2.0)
Sitting during transportation (h)	0.8 (0.0–1.0)*	0.6 (0–2.0)	0.9 (0–1.0)*
Sitting while socializing (h)	1.0 (0–1.0)*	1.0 (0–2.0)	1.0 (0–1.0)*
Total SB (h)	6.5 (5.0–9.0)*	6.0 (4.8–9.3)*	6.5 (5.0–9.0)*

Notes: *Different from the weekday value at $p < 0.05$. Values are presented as median with interquartile range in brackets.

https://doi.org/10.2147/OAJSM.S444862

Table 2 Training, Anthropometric and Physiological Characteristics by Sex and Sedentary Behavior

Parameter	Women (n=29)		Men (n=122)	
	Non-Sedentary (n=16)	Sedentary (n=13)	Non-Sedentary (n=59)	Sedentary (n=63)
Age (years)	42.9±9.5	36.4±8.2*	43.3±10.1	44.3±6.7
Height (cm)	162.5±7.4	163.0±5.4	175.9±4.7	177.2±6.5
Weight (kg)	58.6±6.9	57.0±8.5	76.5±8.6	77.9±9.6
BMI (kg.m^{-2})	22.1±1.6	21.4±2.9	24.7±2.6	24.8±2.5
BF (%)	20.7±4.1	18.5±5.4	17.7±3.8	17.7±4.2
Marathons (n)	2.8±2.1	3.9±5.1	5.6±6.8	5.6±6.3
Marathon record (h:min)	4:34±0:27	4:27±0:49	4:01±0:47	4:03±0:42
Training days (wk^{-1})	4.6±1.1	3.7±1.7*	4.5±1.2	4.2±1.2
Training distance (km.wk^{-1})	51.7±19.1	42.5±26.9	53.6±23.0	52.0±19.1
VO_2max (mL.min^{-1}.kg^{-1})	36.7±7.8	38.5±5.8	48.7±8.4	47.8±8.1
SAR (cm)	25.3±9.4	25.6±7.8	18.1±7.7	17.0±9.3
SJ (cm)	16.8±3.2	18.9±3.8	24.1±4.7	25.0±3.6
CMJ (cm)	17.4±3.7	19.8±3.8	25.8±5.1	26.5±4.3
Pmax (W.kg^{-1})	8.53±0.88	8.88±1.33	10.43±1.67	10.34±1.25

Note: *Different from the non-sedentary score at $p < 0.05$.
Abbreviations: BMI, body mass index; BF, body fat percentage; VO_2max, maximal oxygen uptake; SAR, sit-and-reach test; SJ, squat jump; CMJ, countermovement jump; Pmax, anaerobic power.

Table 3 Correlations (Spearman's Rho) of Training, Anthropometric and Physiological Characteristics with Total Sedentary Behavior by Sex

Parameter	Total Sedentary Behavior (h)	
	Women (n=29)	Men (n=122)
Age (years)	−0.48*	0.07
Height (cm)	−0.08	0.06
Weight (kg)	−0.24	0.08
BMI (kg.m^{-2})	−0.31	0.08
BF (%)	−0.17	0.02
Marathons (n)	−0.14	<0.01
Marathon record (h:min)	−0.08	0.05
Training days (wk^{-1})	−0.17	−0.08
Training distance (km.wk^{-1})	−0.09	−0.07
VO_2max (mL.min^{-1}.kg^{-1})	0.25	−0.10
SAR (cm)	−0.10	−0.01

(*Continued*)

Table 3 (Continued).

Parameter	Total Sedentary Behavior (h)	
	Women (n=29)	Men (n=122)
SJ (cm)	0.49*	0.13
CMJ (cm)	0.42*	0.09
Pmax ($W.kg^{-1}$)	0.36	−0.01

Note: *Statistically significant at $p < 0.05$.
Abbreviations: BMI, body mass index; BF, body fat percentage; VO_2max, maximal oxygen uptake; SAR, sit-and-reach test; SJ, squat jump; CMJ, counter-movement jump; Pmax, anaerobic power.

Level of Sedentary Behavior and Inter-Day Variation

An alarming finding was the high levels of SB (~$9h \cdot day^{-1}$) in the participants. This was lower than that reported in endurance runners,[11] which might be explained using both marathon and half-marathon runners suggesting a sample of more "recreational" athletes. An alarming prevalence of SB was already mentioned in an analysis of post-training activity in football players revealing that most of the post-training activity was spent in sedentary activities.[23] With regards to inter-day variation, we observed a similar trend as in previous research, where total sitting time was higher on workdays than nonwork days (~11 and 8 h, respectively) in marathon and half-marathon runners.[11]

Sedentarism and Physiological Characteristics

The most important finding was that SB did correlate with physiological characteristics. This disagreed with a meta-analysis of 21 original research studies on healthy adults observing a small negative correlation between SB and cardiorespiratory fitness, ie the higher the SB, the lower the cardiorespiratory fitness, and suggesting SB can be associated with poor physical fitness in adults.[10] The evidence found suggested that sedentary time could be associated with poor physical fitness in adults (ie, muscular strength, cardiorespiratory fitness, and balance), so strategies should be created to encourage behavioral changes. However, our findings indicated that regular exercise training might counter-balance this negative role of SB.

Sedentarism and Anthropometric Characteristics

Interestingly, we did not observe any association of SB with indices of fatness such as BMI and BF. However, this finding was in disagreement with a study on athletes, where total screen time – particularly cell phone screen time – was related to BF, ie the more the screen time, the higher the BF.[9] The findings of Judice et al indicated that athletes (age 22 years) with higher amounts of SB presented higher levels of total and trunk fatness, regardless of weekly training time, and it was concluded that even high moderate-to-vigorous PA levels did not mitigate the associations between SB and body fatness in highly trained athletes.[9] In contrast, the lack of association of SB with fatness in the present sample might be attributed to different sample characteristics and qualitative content of SB. For instance, the majority of SB (~60%) during weekdays in our sample was spent in sitting while working.

Sedentarism and Training Characteristics

This finding agreed with a study on marathon and half-marathon runners that observed that SB was not related to training duration or sports performance.[11] Previous research has found that SB was not impacted by high levels of aerobic training in recreational marathon runners.[24] On the other hand, the intensity and duration that older masters and recreational athletes spent in their sport were inversely associated with the amount of sedentary time accumulated in recreational athletes older than 55 years.[25] Future studies might further examine the relationship between training and SB considering our preliminary findings suggesting that these two aspects were not related.

Limitations, Strength and Practical Applications

A limitation of the present study was that – although the anthropometric and physiological characteristics of participants were measured using "direct" assessment methods – SB was evaluated using a questionnaire. It was acknowledged that motion trackers such as accelerometers might provide more detailed information. Furthermore, nutritional and health aspects such as detailed daily food consumption and use of medication were not considered. For instance, nutritional habits have been shown previously to relate with both SB and physical fitness.[26,27] Since these aspects were not controlled in the present study, future research should consider the role of nutrition and health, too.

On the other hand, it should be highlighted that this questionnaire was also previously used to evaluate SB in marathon runners making it possible to compare our data with a study on a similar population.[11] The strength of our research was the sample consisted of a large number of 43-year-old recreational marathon runners. Thus, the findings would have especially practical application in middle age groups. The participants could be considered "newcomers" who can achieve high levels of performance through regular training even at an advanced age, and this benefit can offset performance losses due to a sedentary lifestyle.[28] Accordingly, the findings would have practical applications for researchers and professionals working with marathon runners. So far, there has been little information about the relationship of SB and fitness in marathon runners, and generally in athletes; thus, the results of the present study would be a significant contribution to the limited literature. Moreover, sports federations and coaches may improve athletes' body composition by targeting specific sedentary pursuits, ie total screen time and cell phone screen time, during athletes' recovery time.[9]

Conclusions

Previous findings on the general population indicated an association of high SB with low cardiorespiratory and muscular fitness. Nevertheless, our finding of no correlation between SB and physical fitness in marathon runners suggested that endurance exercise might offset the negative effects of SB. Based on our results, people spending many hours sitting while working should be advised to be involved in regular high-volume exercise training of low-to-moderate intensity. Future studies might examine this topic using a longitudinal study design to verify our findings.

Data Sharing Statement

All data are available by the corresponding author upon reasonable request.

Author Contributions

Pantelis T. Nikolaidis and Beat Knechtle participated equally in the conception, study design, execution, acquisition of data, analysis and interpretation, have drafted, written, and substantially revised and critically reviewed the article. They have agreed on the journal to which the article was submitted, reviewed and agreed on all versions of the article before submission, during revision, the final version accepted for publication, and any significant changes introduced at the proofing stage. Finally, they agree to take responsibility and be accountable for the contents of the article.

Funding

There is no funding to report.

Disclosure

No conflict of interest.

References

1. López-Valenciano A, Mayo X, Liguori G, Copeland RJ, Lamb M, Jimenez A. Changes in sedentary behaviour in European Union adults between 2002 and 2017. *BMC Public Health*. 2020;20(1):1206. doi:10.1186/s12889-020-09293-1
2. Matthews CE, Carlson SA, Saint-Maurice PF, et al. Sedentary behavior in US adults: fall 2019. *Med Sci Sports Exerc*. 2021;53(12):2512–2519. doi:10.1249/MSS.0000000000002751
3. Kanning M, Niermann C, Ebner-Primer U, Giurgiu M. The context matters - not all prolonged sitting bouts are equally related to momentary affective states: an ambulatory assessment with sedentary-triggered E-diaries. *Int J Behav Nutr Phys Act*. 2021;18(1):106. doi:10.1186/s12966-021-01170-3

4. Sansano-Nadal O, Giné-Garriga M, Rodríguez-Roca B, et al. Association of self-reported and device-measured sedentary behaviour and physical activity with health-related quality of life among European older adults. *Int J Environ Res Public Health*. 2021;18(24):182413252. doi:10.3390/ijerph182413252
5. Memon AR, Stanton R, To Q, et al. Sedentary behaviour research in adults: a scoping review of systematic reviews and meta-analyses. *J Sports Sci*. 2021;39(19):2219–2231. doi:10.1080/02640414.2021.1928382
6. Vitti A, Nikolaidis PT, Villiger E, Onywera V, Knechtle B. The "New York City Marathon": participation and performance trends of 1.2M runners during half-century. *Res Sports Med*. 2020;28(1):121–137. doi:10.1080/15438627.2019.1586705
7. Knechtle B, Di Gangi S, Rüst CA, Nikolaidis PT. Performance differences between the sexes in the Boston marathon from 1972 to 2017. *J Strength Cond Res*. 2020;34(2):566–576. doi:10.1519/JSC.0000000000002760
8. Reusser M, Sousa CV, Villiger E, et al. Increased participation and decreased performance in recreational master athletes in "Berlin Marathon" 1974–2019. *Front Physiol*. 2021;12(631237). doi:10.3389/fphys.2021.631237
9. Júdice PB, Hetherington-Rauth M, Magalhães JP, Correia IR, Sardinha LB. Sedentary behaviours and their relationship with body composition of athletes. *Eur J Sport Sci*. 2022;22(3):474–480. doi:10.1080/17461391.2021.1874060
10. Silva FM, Duarte-Mendes P, Rusenhack MC, et al. Objectively measured sedentary behavior and physical fitness in adults: a systematic review and meta-analysis. *Int J Environ Res Public Health*. 2020;17(22):17228660. doi:10.3390/ijerph17228660
11. Whitfield G, Pettee Gabriel KK, Kohl HW. Sedentary and active: self-reported sitting time among marathon and half-marathon participants. *J Phys Act Health*. 2014;11(1):165–172. doi:10.1123/jpah.2011-0420
12. Franssen WMA, Vanbrabant E, Cuveele E, Ivanova A, Franssen G, Eijnde BO. Sedentary behaviour, physical activity and cardiometabolic health in highly trained athletes: a systematic review and meta-analysis. *Eur J Sport Sci*. 2022;22(10):1605–1617. doi:10.1080/17461391.2021.1955013
13. Exel J, Mateus N, Abrantes C, Leite N, Sampaio J. Physical activity and sedentary behavior in amateur sports: master athletes are not free from prolonged sedentary time. *Sport Sci Health*. 2019;15(2):385–391. doi:10.1007/s11332-019-00527-3
14. Nikolaidis PT, Chalabaev A, Rosemann T, Knechtle B. Motivation in the Athens classic marathon: the role of sex, age, and performance level in Greek recreational marathon runners. *Int J Environ Res Public Health*. 2019;16(14):16142549. doi:10.3390/ijerph16142549
15. Nikolaidis PT, Clemente-Suárez VJ, Chlíbková D, Knechtle B. Training, anthropometric, and physiological characteristics in men recreational marathon runners: the role of sport experience. *Front Physiol*. 2021;12:666201. doi:10.3389/fphys.2021.666201
16. Nikolaidis PT, Rosemann T, Knechtle B. Development and validation of prediction equation of "Athens Authentic Marathon" Men's race speed. *Front Physiol*. 2021;12:682359. doi:10.3389/fphys.2021.682359
17. Whitfield GP, Gabriel KK, Kohl HW. Assessing sitting across contexts: development of the multicontext sitting time questionnaire. *Res Q Exerc Sport*. 2013;84(3):323–328. doi:10.1080/02701367.2013.814041
18. Roake J, Phelan S, Alarcon N, Keadle SK, Rethorst CD, Foster GD. Sitting time, type, and context among long-term weight-loss maintainers. *Obesity*. 2021;29(6):1067–1073. doi:10.1002/oby.23148
19. Han H, Pettee GK, Kohl HW, Buchowski M. Application of the transtheoretical model to sedentary behaviors and its association with physical activity status. *PLoS One*. 2017;12(4):e0176330. doi:10.1371/journal.pone.0176330
20. Walker TJ, Heredia NI, Lee M, et al. The combined effect of physical activity and sedentary behavior on subclinical atherosclerosis: a cross-sectional study among Mexican Americans. *BMC Public Health*. 2019;19(1):161. doi:10.1186/s12889-019-6439-4
21. Durand CP, Oluyomi AO, Gabriel KP, et al. The effect of light rail transit on physical activity: design and methods of the travel-related activity in neighborhoods study. *Front Public Health*. 2016;4:103. doi:10.3389/fpubh.2016.00103
22. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. *Med Sci Sports Exerc*. 2009;41(1):3–13. doi:10.1249/MSS.0b013e31818cb278
23. Weiler R, Aggio D, Hamer M, Taylor T, Kumar B. Sedentary behaviour among elite professional footballers: health and performance implications. *BMJ Open Sport Exerc Med*. 2015;1(1):e000023. doi:10.1136/bmjsem-2015-000023
24. Swartz AM, Miller NE, Cho YI, Welch WA, Strath SJ. A prospective examination of the impact of high levels of exercise training on sedentary behaviour. *Eur J Sport Sci*. 2017;17(2):222–230. doi:10.1080/17461391.2016.1251496
25. McCracken H, Dogra S. Sedentary time in male and female masters and recreational athletes aged 55 and older. *J Aging Phys Act*. 2018;26(1):121–127. doi:10.1123/japa.2016-0324
26. Sandri E, Cantín Larumbe E, Part-Ferrer R, Ferrer-Torregrosa J, Fernández-Ehrling N. Diet and lifestyle in the Spanish population and their relationship with sociodemographic variables: a descriptive study. *Foods*. 2023;12(18):3409. doi:10.3390/foods12183409
27. Longo UG, Sofi F, Dinu M, et al. Alpine junior world ski championship: nutritional habits and performance in elite skiers. *J Sports Med Phys Fitness*. 2019;59(8):1339–1345. doi:10.23736/S0022-4707.19.09386-1
28. Leyk D, Rüther T, Wunderlich M, et al. Physical performance in middle age and old age: good news for our sedentary and aging society. *Dtsch Arztebl Int*. 2010;107(46):809–816.