REABILITACIJOS MOKSLAI
Slauga, kineziterapija, ergoterapija
LITHUANIAN SPORTS UNIVERSITY

Reabilitacijos mokslai: slauga, kineziterapija, ergoterapija, *1*(34) 2026, 1–11, eISSN 2538-8673; DOI: https://doi.org/10.33607/rmske.v1i34.2264

Changes in Physical Fitness, Physical Activity, and Sleep Among Adolescents During a Riflemen Summer Camp: A Pilot Study

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Abstract

Background. Physical health of adolescents is increasingly challenged by sedentary lifestyles and insufficient physical activity in a technology-driven society. Structured, physically demanding summer camps may help improve youth physical fitness, activity levels, and sleep, but evidence on Lithuanian Riflemen summer camps is lacking.

Aim. To determine the effects of a Riflemen summer camp on adolescents' physical fitness, physical activity, and sleep parameters.

Methods. Twelve adolescents (age 13.8 ± 1.2 years) attending their first Riflemen summer camp participated in the study. Physical activity (daily step count) and sleep duration were monitored with Xiaomi Mi Smart Band 6 bracelets for seven days before the camp, throughout the seven-day camp, and for seven days after the camp. Physical fitness (90–90 Test, Apley Scratch Test, Sit-To-Stand, Partial Curl-Up, and Single-Leg Stance Test – eyes closed) was assessed on the first and last day of the camp.

Results. After the camp, significant improvements were observed in abdominal and lower-limb muscle strength, static balance, and shoulder mobility ($p < 0.05$). Mean daily steps during the camp reached approximately 12,000, almost double the pre-camp level (~6,500; $p < 0.05$). Post-camp step counts significantly decreased ($p < 0.05$) and did not differ from baseline ($p > 0.05$). Sleep duration shortened during the camp ($p < 0.05$), whereas after the camp both total and deep sleep time were significantly longer than before the camp ($p < 0.05$).

Conclusions. A structured seven-day Riflemen summer camp may induce short-term changes in adolescents' physical fitness, daily step counts, and subsequent sleep duration.

Keywords: Adolescents; summer camp; physical fitness; physical activity; sleep duration

1. INTRODUCTION

In the current European context, marked by ongoing military conflict and renewed attention to national defence, the preparation of young people for potential civic and defence roles has become particularly relevant. Youth organisations that strengthen physical fitness, resilience, and civic engagement are strategically important for national security and social cohesion (Lietuvos Respublikos švietimo ir mokslo ministras, 2017). The Lithuanian Riflemen's Union organises summer camps that combine intensive daily physical activity, structured routines, and health-promoting practices with education on national security, first aid, teamwork, and civic responsibility (Lithuanian Riflemen's Union, 2026).

These camps may, therefore, contribute not only to defence readiness but also to adolescents' physical and mental health. Understanding the health-related effects of such programmes requires consideration of key movement and recovery behaviours in adolescence.

Adolescence is a critical period for the development of lifelong health behaviours, yet recent evidence shows that many young people do not attain sufficient levels of physical activity and have suboptimal physical health profiles. Insufficient physical activity in teenagers is associated with excess weight, adverse anthropometric indicators, and early cardiometabolic risk (Bull et al., 2020; Jia & Li, 2021). Global data indicate that approximately 81% of adolescents are not sufficiently active, highlighting a persistent public health concern (Bull et al., 2020; Chaput et al., 2020). At the same time, the increasing use of digital technologies and screen-based leisure further promotes sedentary lifestyles and may contribute to deteriorating physical fitness and unhealthy routines among teenagers (Jia & Li, 2021; Klavina et al., 2023).

Sleep health represents another cornerstone of adolescent wellbeing. Recent studies have linked insufficient and poor-quality sleep with poorer physical fitness, reduced daytime functioning, and increased psychological difficulties (Kasmadi & Suhadi, 2024). Modern lifestyles, high academic demands, late bedtimes, and extensive use of electronic devices contribute to shortened sleep duration and irregular sleep patterns in adolescents (Kasmadi & Suhadi, 2024). Emerging research also underscores the growing role of consumer wearables in monitoring sleep quantity and quality in real-world settings, although their accuracy remains imperfect (Chinoy et al., 2021; de Zambotti et al., 2019).

Physical activity and sleep are increasingly conceptualised within a 24-hour movement behaviour framework, where moderate-to-vigorous activity, sedentary time, and sleep jointly shape health outcomes (Bull et al., 2020; Chaput et al., 2020). Higher physical activity has been associated with better sleep quality and more favourable mental health outcomes, while adherence to integrated 24-hour guidelines appears protective against risk behaviours and psychological difficulties (Kasmadi & Suhadi, 2024; Lang et al., 2013). These findings highlight the need for interventions that target both movement and recovery behaviours in adolescence.

Structured environments, such as summer programmes and camps, offer a promising setting for modifying multiple health behaviours simultaneously. Recent reviews and intervention studies suggest that health-oriented summer camps can improve anthropometric and cardiovascular indicators, increase physical fitness, and promote healthier lifestyle habits among children and adolescents (Larose et al., 2023; Marques et al., 2021). However, most of this research has focused on general health promotion or obesity management, and very few studies have investigated physically intensive, discipline-oriented camps that include civic and defence-related training.

Despite this potential, scientific evidence on the health effects of Lithuanian Riflemen summer camps remains scarce. In particular, little is known about how participation in such camps affects adolescents' physical fitness, objectively measured physical activity, and sleep duration and quality within a unified 24-hour behaviour framework. Existing literature rarely examines these outcomes together, limiting understanding of the combined impact on movement and recovery domains of adolescent health (Bull et al., 2020; Kasmadi & Suhadi, 2024; Marques et al., 2021). The aim of this study was to determine the impact of a Lithuanian Riflemen summer camp on adolescents' physical fitness, physical activity, and sleep parameters.

2. METHODS

2.1. Participants and ethical approval

This study included 12 adolescents (six girls and six boys) aged 12–17 years who were members of the Lithuanian Riflemen's Union youth group and attended their first Lithuanian Riflemen summer camp (Suvalkija Riflemen's 4th Battalion, education levels I–II (introductory stages) of the Lithuanian Riflemen's Union four-level (I–IV) programme). Convenience sampling was applied. The mean age of the participants was 13.8 ± 1.2 years, with a mean height of 1.6 ± 0.2 m and body weight of 63.8 ± 14.5 kg. The mean waist-to-height ratio was 0.48 ± 0.06, with no statistically significant differences between girls and boys in any baseline characteristics ($p > 0.05$).

Ethical approval for the study was obtained from the Bioethics Committee of the Kauno kolegija Higher Education Institution, Department of Rehabilitation (No. 2/24/25). The study was conducted in accordance with the principles of the Declaration of Helsinki.

2.2. Study design and procedure

The study employed a prospective quasi-experimental intervention design. Monitoring of physical activity and sleep started seven days before the beginning of the summer camp. From this date, participants were instructed to wear a Xiaomi Mi Smart Band 6 bracelet and to synchronise it daily with "Zepp Life" mobile application. Each day, they sent their sleep data and daily step count to the researcher via an agreed electronic channel, in line with previous work using consumer wearables to assess sleep and activity (Chinoy et al., 2021; de Zambotti et al., 2019).

The camp lasted seven consecutive days. On the first morning of the camp, participants completed a short questionnaire. Body weight and waist circumference were measured, followed by baseline physical fitness testing. After testing, adolescents joined regular camp routine, which included structured daily physical activities and organised programme elements (Table 1), including scheduled wake-up, morning exercise, meals, and organised training blocks. Physical activities were integrated into several daily sessions (e.g. drills, team tasks, sport competitions, marches/hikes), with the exact content varying by day according to the official timetable. Throughout the camp, participants continued to submit daily data from their smart bracelets. On the last morning of the camp, the same physical fitness test battery was repeated in the same order as at baseline.

Table 1. **Daily schedule and activity classification during the camp programme**

Time block	Activity (examples)	Classification
7:00	Wake-up	Routine
7:10–7:30	Morning exercise	Structured physical activity
8:30	Breakfast	Routine
9:30–12:30	Training/education blocks (e.g. drills, skills)	Mixed (specify)
13:00	Lunch	Routine
14:30–18:00	Field training / physical sessions (e.g. obstacle tasks, water activities, shooting practice)	Structured physical activity (where applicable)
18:30	Dinner	Routine
19:30–22:15	Evening programme (team tasks/games/sport competitions)	Structured physical activity
23:00–7:00	Lights out/sleep	Routine

Post-camp monitoring continued for seven days. During this phase, participants again wore the smart bracelet and submitted daily data on sleep and step count to the researcher using the same procedure as before the camp.

2.3. Outcome measures

2.3.1. Anthropometry

Waist circumference was measured with a flexible tape at the level of the umbilicus after gentle expiration, without drawing in the abdomen. Waist-to-height ratio was calculated as waist circumference (cm) divided by height (cm); values <0.50 were considered within the normal range.

2.3.2. Physical fitness evaluation

During Hamstring flexibility, 90–90 Test participants laid supine on a mat. The test leg was flexed to 90° at the hip and knee and stabilised with hands, while the contralateral leg remained extended and in contact with the floor. The participant was asked to extend the knee as far as possible. The knee extension angle was measured with a goniometer. Each leg was tested three times, and the mean value was used for further analysis (Nelson & Bandy, 2004). A knee extension of more than 20° from the 90° position was considered the normal range of motion (Norkin & White, 2009).

Shoulder mobility was assessed with the Apley Scratch Test. Standing upright, participants reached one hand over the shoulder and down the back, and the other hand up the back from below, attempting to touch the fingers. Both sides were assessed. Shoulder mobility was evaluated by the distance between the fingertips. Contact or a gap of ≤5 cm was considered normal; 5–10 cm indicated slightly restricted movement; >10 cm indicated limited shoulder mobility. Side-to-side differences >5 cm were regarded as clinically relevant asymmetry (Woodward & Best, 2000).

Lower-limb muscle strength was assessed using the repeated Sit-To-Stand Test. Participants sat in the middle of a standard-height (approximately 43–45 cm) armless chair, with feet flat on the floor, knees flexed to 90°, and arms crossed over the chest. On the command "Start", they were instructed to stand up fully and sit down ten times as quickly as possible while keeping the trunk upright. Time was recorded with a stopwatch from the initial standing movement until completion of the last sit-down.

Abdominal muscle strength was assessed using the Partial Curl-Up Test. Participants lay supine on a mat with knees flexed to 90°, feet flat on the floor, and arms extended alongside the trunk. From this position, they lifted their head and shoulders to touch the patella with their fingertips, and then returned to the starting position. The number of correctly performed partial curl-ups in 1 min was recorded (Brox et al., 2005). Results were interpreted primarily as within-subject change across the study period.

Static balance was assessed using the Single-Leg Stance Test, performed with eyes closed on a firm surface while wearing shoes. Participants stood with their feet shoulder-width apart and their arms at their sides. They then lifted one leg off the floor (knee flexed ~40°, hip ~20°) and closed their eyes. Time was recorded until the raised foot touched the ground or the eyes were opened. Both legs were tested, and performance was interpreted primarily as within-subject change across the study period (Muehlbauer et al., 2022).

2.3.3. Physical activity and sleep parameters

Physical activity and sleep were measured using the Xiaomi Mi Smart Band 6 bracelets. Data were recorded and viewed via the "Zepp Life" mobile application. The following parameters were collected daily: mean daily step count (steps/day), total sleep duration (hours), and deep sleep duration (hours) (Chinoy et al., 2021; de Zambotti et al., 2019).

2.4. Statistical analysis

Data were analysed using IBM SPSS Statistics, version 22.0, and Microsoft Excel 2016. Descriptive statistics are presented as mean ± standard deviation (SD). The normality of data distribution was evaluated using the Kolmogorov–Smirnov Test. For comparisons between two dependent measurements (e.g. pre- vs. post-camp physical fitness, pre-camp vs. camp, and pre-camp vs. post-camp step counts and sleep parameters), paired-samples *t* tests were used, as the data met normality assumptions. Statistical significance was set at $p < 0.05$.

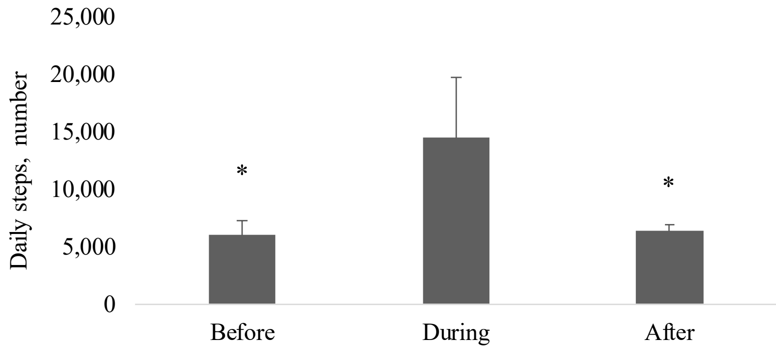
3. RESULTS

Changes in flexibility, strength, and balance over the camp period are presented in Table 1. Hamstring flexibility did not change significantly ($p > 0.05$). Shoulder mobility improved, as indicated by a reduction in fingertip-to-fingertip distance for both arms ($p < 0.05$). Lower-limb muscle strength increased, reflected by a shorter time to complete ten sit-to-stand repetitions ($p < 0.05$). Abdominal muscle strength also increased, as shown by a higher number of curl-ups performed in one minute ($p < 0.05$). Static balance improved in both legs (both $p < 0.05$; Table 2).

Table 2. **Changes in physical fitness parameters over the camp period**

Tests	**Before camp mean ± SD**	**Post camp mean ± SD**	***p*-value**
Hamstring flexibility (degrees)			
Left leg	142.3 ± 17.0	144.8 ± 16.5	0.518
Right leg	144.9 ± 14.0	147.4 ± 13.4	0.432
Shoulder mobility (cm)			
Left shoulder	10.5 ± 6.1	8.4 ± 5.5	0.043
Right shoulder	8.5 ± 5.5	7.3 ± 4.7	0.049
Static balance (s)			
Left leg	19.2 ± 9.4	25.4 ± 12.1	0.031
Right leg	20.1 ± 11.1	30.9 ± 15.4	0.006
Sit-To-Stand Test (s)	18.8 ± 2.4	15.7 ± 2.67	0.000
Partial curl up (repetitions)	31.3 ± 10.4	35.4 ± 10.6	0.041

Physical activity, assessed by mean daily step counts, increased markedly during the camp. The mean number of steps rose from 5,938.3 ± 1,286.36 before the camp to 14,443.52 ± 5,294.36 during the camp, and then decreased to 6,333.1 ± 530.96 after the camp. The increase from the 'before' to the 'during' period and the decrease from the 'during' to the 'after' period were statistically significant (both $p < 0.05$), whereas the difference between the 'before' and 'after' periods was not ($p > 0.05$) (Figure 1).

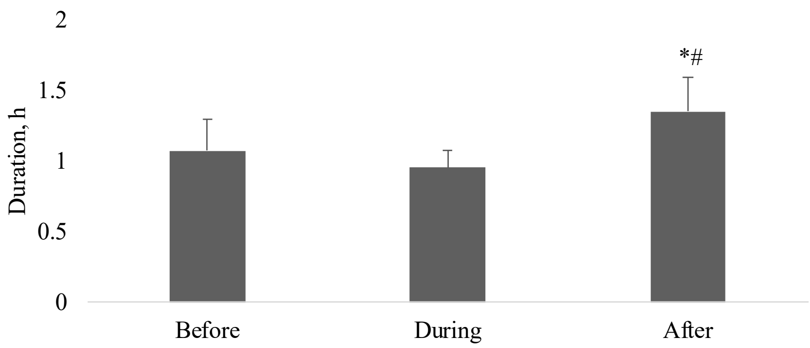


Note: *$p < 0.05$ compared with values during the camp

Figure 1. **Changes in mean daily step counts before, during, and after the camp**

Mean total sleep duration decreased from 8.5 ± 0.5 h before the camp to 7.3 ± 0.3 h during the camp, and then increased to 8.8 ± 0.9 h after the camp. Sleep time was significantly shorter during the camp compared with before and after (both $p < 0.05$), whereas the difference between the 'before' and 'after' periods was not significant ($p > 0.05$).

Deep sleep showed a similar pattern: mean duration was 1.07 ± 0.22 h before the camp, 0.95 ± 0.12 h during the camp, and 1.35 ± 0.27 h after the camp. The increase from the 'during' to the 'after' period and from 'before' to 'after' was statistically significant (both $p < 0.05$), while the difference between 'before' and 'during' was not ($p > 0.05$). Deep sleep accounted for 12.6% of total sleep before the camp, 13.0% during the camp, and 15.3% after the camp (Figure 2).



Note: *$p < 0.05$ compared with values during the camp, #$p < 0.05$ for the comparison between pre- and post-camp values.

Figure 2. **Changes in deep sleep duration before, during, and after the camp**

4. DISCUSSION

This study examined how participation in a Lithuanian Riflemen summer camp affected adolescents' physical fitness, daily physical activity, and sleep. The main findings were that muscle strength and static balance improved significantly over the camp period, daily step counts almost tripled during the camp but returned close to baseline afterwards, and sleep duration decreased temporarily during the camp while both total sleep and deep sleep increased after the camp.

Improvements in shoulder mobility, abdominal muscle strength, and single-leg balance time show that even a short, seven-day intervention combining regular morning exercise with a physically demanding camp routine can positively affect neuromuscular function in adolescents. These findings are in line with evidence that structured resistance and functional training in youth improve strength, mobility, and postural control, and support healthy musculoskeletal development (Faigenbaum et al., 2009; Marques et al., 2021; Muehlbauer et al., 2022).

Static balance, assessed by Single-Leg Stance Test with eyes closed, improved on both legs, with one side reaching commonly suggested thresholds for good balance. These findings align with evidence that repeated practice of challenging balance tasks can substantially enhance postural control in young people (Muehlbauer et al., 2022) and that physically demanding, variable outdoor environments can further support the development of balance and other components of motor competence (Johnstone et al., 2022). Taken together, the changes in strength and balance observed in the present study are consistent with contemporary work on the functional muscle–bone unit, which highlights muscle forces and weight-bearing physical activity during growth as key determinants of bone mass and bone strength in youth (Kwon et al., 2025; Ludwa et al., 2021; Zhang et al., 2024). Balance outcomes in adolescents may also be influenced by trunk stability (Budrienė & Gudaitė, 2022; Budryte et al., 2024).

Daily physical activity increased most markedly during the camp. Mean step counts rose from clearly insufficient levels before the camp to values within or slightly above the 11,000–14,000 steps per day range often associated with health-promoting activity in children and adolescents (Adams et al., 2013). Before and after the camp, step counts were closer to the global pattern, where most adolescents do not meet physical activity guidelines (Bull et al., 2020; Chaput et al., 2020). The fact that post-camp values returned close to baseline, with only a small residual increase, is similar to other camp and after-school interventions in which strong effects are observed during the programme but diminish once the structured environment is removed (Beets et al., 2017; Larose et al., 2023). This underlines both the potential and the limitations of short, intensive interventions: they can temporarily shift behaviour to more active patterns, but additional strategies are needed to support long-term maintenance.

Sleep outcomes showed a more complex but ultimately favourable pattern. During the camp, total sleep duration decreased to slightly below the recommended 8–10 hours per night for adolescents (Paruthi et al., 2016), which is consistent with broader concerns that many adolescents sleep less than recommended. After the camp, however, total sleep time increased again and slightly exceeded baseline values. Deep sleep duration and its proportion of total sleep were also the highest in the post-camp period, approaching the lower end of the range generally considered optimal for restorative slow-wave sleep and overall health (Besedovsky et al., 2012; Paruthi et al., 2016). Because deep sleep is critical for physical recovery, immune function, and cognitive performance (Besedovsky et al., 2012), this shift may suggest an improvement in sleep quality rather than just a return to baseline quantity. However, an alternative explanation of this finding is that the post-camp increase in total sleep time and deep sleep may partly reflect compensatory recovery (sleep rebound) following sleep restriction during camp. Homeostatic sleep regulation predicts enhanced slow-wave related sleep after deprivation (Borbély, 2022).

The transient reduction in sleep during the camp may reflect early wake times, increased physical load, and adaptation to a new, disciplined environment. The subsequent rebound in both total and deep sleep is consistent with studies showing that regular physical activity, structured routines, and reduced evening screen time contribute to better sleep in adolescents (Lang et al., 2013; Minges & Redeker, 2016; Kasmadi & Suhadi, 2024). Importantly, this study used wrist-worn consumer devices to monitor sleep and step counts. Although such devices are less accurate than polysomnography for detailed sleep staging, they provide reasonable estimates of sleep duration and activity patterns in free-living conditions and are increasingly used in paediatric research (Chandler et al., 2016; Chinoy et al., 2021; de Zambotti et al., 2019). Their use here enabled continuous tracking before, during, and after the camp.

Several limitations should be considered when interpreting these findings. The sample size was small, reducing statistical power and limiting generalisability. In addition, participants were recruited via convenience sampling from a Lithuanian Riflemen's Union youth group, which may introduce selection bias and limit applicability to the general adolescent population. The camp programme was short, making it difficult to produce large or sustained changes in all fitness domains. The lack of a control group means that maturation and other unmeasured factors cannot be completely ruled out as contributors to the observed changes. Age- and sex-specific normative reference values for the 10-repetition timed Sit-To-Stand Test in adolescents are limited and protocol-dependent; therefore, this outcome was interpreted primarily as within-subject change. Regarding measurement, physical activity was primarily quantified using step counts from a consumer wearable; this metric does not capture exercise intensity or some non-ambulatory activities, and device algorithms may introduce error. Sleep outcomes should also be interpreted cautiously, as the post-camp increase in sleep duration may partly reflect compensatory recovery (rebound) after shorter sleep during camp. Finally, the field-based tests and wearable devices, although practical, are less precise than laboratory methods (de Zambotti et al., 2019; Chinoy et al., 2021; Marques et al., 2021). Despite these limitations, the study provides preliminary evidence that a short, physically intensive Lithuanian Riflemen summer camp is a promising real-world setting for promoting physical fitness, increasing daily activity, and supporting better sleep quality in adolescents.

From a practical perspective, these findings suggest that Riflemen-type summer camps could play a useful role in broader adolescent health promotion strategies, especially in contexts where physical preparedness, discipline, and civic engagement are considered important (Lietuvos Respublikos švietimo ir mokslo ministras, 2017; Lithuanian Riflemen's Union, 2026). Future research with larger samples, longer interventions, and follow-up assessments is needed to determine whether repeated participation in such camps or integration of similar structured programmes into schools and communities can produce more durable and clinically meaningful benefits in physical fitness, physical activity, and sleep.

5. CONCLUSIONS AND PERSPECTIVES

Participation in the Lithuanian Riflemen summer camp was associated with short-term improvements in physical fitness among adolescents, reflected in increased muscle strength and enhanced static balance. Step counts increased during the camp and returned to baseline afterwards. Post-camp total and deep sleep duration exceeded pre-camp values, although these findings should be interpreted cautiously given the pilot design.

Future studies should include larger samples and longer follow-up periods to determine whether the observed improvements in physical fitness, physical activity, and sleep can be maintained over time. It would also be relevant to examine psychological outcomes (e.g. wellbeing, resilience, stress) and to explore whether repeated participation in Riflemen camps or similar structured programmes could lead to more stable and clinically meaningful health benefits in adolescents.

Author Contributions: Conceptualisation, L.M. and L.Ž.; methodology, L.M.; formal analysis, L.Ž.; investigation, A.K.; resources, A.K.; data curation, A.K.; writing—original draft preparation, L.M.; writing—review and editing, L.Ž. and A.K.; visualisation, A.K.; supervision, L.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflict of interest.

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Received 2025 12 21
Accepted 2026 02 02