

Effects of a six-month combined educational and physical activity program on physical fitness, body composition, sleep quality, and quality of life among university ice-hockey players and recreationally active adults

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Abstract

Contemporary physiotherapy is increasingly moving beyond the reactive treatment of injury toward the primary prevention of disease and the proactive promotion of long-term health. Although educational interventions addressing sleep, nutrition, circadian hygiene, and recovery are frequently recommended, empirical evidence regarding their combined effects with physical activity among already physically active populations remains limited. Therefore, this study examined the effects of a six-month program integrating health education and physical activity on physical fitness, body composition, self-reported sleep quality, and quality of life in two groups of physically active adults. Thirty-four participants (33 men and 1 woman, aged 19-41 years) were assigned to two parallel groups: players from the university ice hockey team, CTU Engineers Prague (Group A, n = 17), and members of a recreational fitness community (Group B, n = 17). Both groups completed the same program, consisting of expert-led seminars on sleep and light hygiene, nutrition, stress management, psychosomatic relationships, circadian rhythmicity, and recovery, combined with habitual physical activity and individualized physiotherapy supervision. Body composition was assessed using direct segmental multi-frequency bioelectrical impedance analysis. Physical fitness was evaluated with a three-item battery consisting of air bike interval performance, passive bar hang, and one-repetition-maximum deadlift tests. Sleep quality and quality of life were assessed using the Pittsburgh Sleep Quality Index (PSQI) and the WHOQOL-BREF questionnaire. Measurements were repeated after six months. Body composition remained essentially unchanged in both groups (all $p > 0.30$). Physical fitness improved significantly in every test in both groups: deadlift strength increased by 8.0 kg in Group A ($p = 0.003$) and 11.4 kg in Group B ($p < 0.001$); air bike performance improved by 6.7 kcal ($p = 0.004$) and 11.0 kcal ($p < 0.001$), respectively; and passive hang endurance increased by 6.0 s ($p = 0.044$) and 14.3 s ($p = 0.015$), with a markedly greater relative improvement in Group B (+25.7% versus +10.4%). Quality of life and sleep quality improved significantly only in Group B, with WHOQOL-BREF scores increasing from 72.9% to 83.0% ($p = 0.008$) and PSQI scores decreasing from 2.8 to 1.4 points ($p = 0.005$). In Group A, improvements were more favorable but did not reach statistical significance, which may reflect a ceiling effect and the demands of the concurrent competitive season. Baseline analyses revealed a strong inverse association between body fat percentage and passive hang endurance ($r = -0.65$, $p < 0.001$). A combined educational and physical activity program delivered by a physiotherapist can improve muscular strength and anaerobic performance and, in recreationally active adults, enhance perceived sleep quality and quality of life without inducing measurable changes in body composition.

Key words: preventive physiotherapy, health education, ice hockey, sleep quality, quality of life

Introduction

The role of the physiotherapist has broadened considerably over the past two decades. Whereas the profession was historically defined by the restoration of function after injury or disease, contemporary practice increasingly incorporates primary prevention, health education, and the long-term maintenance of functional capacity. This reorientation reflects the accumulated evidence that structured physical activity acts as an effective therapeutic intervention across a wide spectrum of chronic conditions, with documented efficacy in psychiatric, neurological, metabolic, cardiovascular, pulmonary, musculoskeletal, and oncological diseases (Pedersen & Saltin, 2015). The same body of evidence underpins the current World Health Organization recommendations, which specify 150 to 300 minutes of moderate-intensity or 75 to 150 minutes of vigorous-intensity aerobic activity per week, together with muscle-strengthening activity on two or more days, for all adults, including those living with chronic conditions or disabilities (Bull et al., 2020). The resistance-training component of these recommendations is supported by meta-analytic evidence demonstrating that muscle-strengthening activity is associated with a lower risk of all-cause mortality and major non-communicable diseases, independently of aerobic activity (Momma et al., 2022). If exercise can be prescribed as medicine, the

physiotherapist is uniquely positioned to act not only as the clinician who prescribes and supervises exercise but also as the educator who explains why it works and how it can be integrated into daily life.

Muscular strength has emerged as one of the most robust indicators of general health. In a prospective cohort of more than half a million UK Biobank participants, every 5 kg decrement in handgrip strength was associated with a higher hazard of all-cause mortality and cardiovascular, respiratory, and oncological outcomes, and the addition of grip strength improved the discriminative ability of an established office-based risk score (Celis-Morales et al., 2018). On the basis of such findings, handgrip strength has been proposed as a new vital sign of health, applicable across the lifespan and sensitive to sarcopenia, frailty, nutritional status, and quality of life (Vaishya et al., 2024). Comparable associations between grip strength and health-related quality of life have been reported in community-dwelling older adults (Halaweh, 2020), while in clinical populations, low skeletal muscle mass has been linked to poorer global and physical-functioning quality-of-life scores (Hanna et al., 2022). The interpretation of individual measurements has recently been placed on a firmer footing by international normative data assembled from 2.4 million adults aged 20 years and older across 69 countries and regions (Tomkinson et al., 2025). Whether these associations, established largely in older or clinical populations, are also detectable in young, physically active adults remains unclear.

Body composition is a second domain in which physiotherapeutic education is frequently expected to produce change. The available evidence suggests that this expectation warrants qualification. In a sample of 605 young Spanish adults, physical activity was consistently associated with fat-free mass but showed no association with fat mass, which was instead related to dietary factors (Correa-Rodriguez et al., 2017). A cross-sectional study of 271 Croatian university students similarly showed that although physical activity was positively associated with fat-free mass, adiposity was jointly determined by self-rated health, dietary pattern, substance use, and psychological distress (Štefan et al., 2017). Body composition therefore appears to be a comparatively resistant outcome over the short to medium term unless a targeted nutritional intervention is added. A further consideration is measurement: outside the laboratory, body composition is monitored predominantly by bioelectrical impedance analysis, which is inexpensive, rapid, and repeatable, and whose agreement with reference methods continues to be evaluated in validation studies (van den Helder et al., 2022).

Sleep constitutes a third pillar of preventive care and is now recognized as a determinant of both health and performance. Sleep loss impairs sport-specific performance, disturbs autonomic balance in a manner resembling overtraining syndrome, promotes pro-inflammatory signaling, and degrades cognitive function (Fullagar et al., 2015). Athletes nevertheless routinely fail to obtain the recommended sleep duration and are poor judges of their own sleep, which argues for systematic monitoring and intervention (Watson, 2017). At the population level, an umbrella review of 29 systematic reviews and meta-analyses confirmed that habitually short sleep is associated with increased all-cause mortality, cardiovascular disease, obesity, and type 2 diabetes, as well as with elevated anxiety and depressive symptomatology (Shah et al., 2025), and mechanistic work has linked sleep disruption to circadian gene expression, glucose and lipid metabolism, inflammatory signaling, and the gut microbiome (Hong et al., 2025). Expert consensus now recommends that athlete-support programs incorporate routine sleep screening, sleep education, and individually targeted interventions rather than generic advice (Walsh et al., 2021), and a systematic review of sleep interventions designed to improve athletic performance and recovery identified sleep extension, napping, and sleep hygiene education as the principal approaches tested thus far while drawing attention to the methodological heterogeneity of the available studies (Bonnar et al., 2018).

One specific and readily modifiable determinant of sleep is evening light exposure. Controlled laboratory work has shown that exposure to a light-emitting diode-backlit computer screen in the evening suppresses melatonin secretion and increases subjective alertness and cognitive performance at a time of day when the organism should be preparing for sleep (Cajochen et al., 2011). Subsequent work using metameric displays has demonstrated that it is the melanopic component of the emitted light, rather than its photopic illuminance as such, that governs the prolongation of sleep latency, the suppression of melatonin, and the increase in alertness (Schöllhorn et al., 2023). Light hygiene is therefore an attractive target for education: the behavior is widespread, the underlying mechanism is well understood, and the required behavioral modification is inexpensive.

Ice hockey represents a demanding model in which to examine these questions. Match play consists of repeated 30–80-s shifts performed at near-maximal skating intensity, taxing both aerobic and anaerobic energy systems and producing pronounced muscle glycogen depletion, including within individual fast- and slow-twitch fibers; high-intensity skating capacity declines in the final stages of a game and repeated-sprint ability is impaired post-match (Vigh-Larsen & Mohr, 2024). Ice-hockey players therefore combine a high habitual training load with a competitive schedule that constrains sleep, nutrition, and recovery, and constitute a population in which educational intervention might plausibly be either particularly valuable or particularly difficult to implement. The competitive schedule itself appears to matter: in collegiate men's ice hockey, the workload accumulated in the period preceding a fixture has been shown to be related to subsequent team performance (Neeld et al., 2021), which places the management of load and recovery among the determinants of competitive outcome rather than among its peripheral concerns.

Evidence that structured education can shift health-relevant outcomes outside the clinic is accumulating. The Structured Health Intervention For Truckers trial delivered a combined educational and physical activity program to heavy goods vehicle drivers, an occupational group whose working day severely constrains both activity and sleep, and its mixed-methods process evaluation identified the structure of that working day, rather than any deficit of knowledge, as the principal barrier to implementation (Guest et al., 2022). Our own group has approached related questions in several populations. In a multicenter study of physiotherapy students in a number of European countries, quality of life and quality of education were assessed with validated instruments, which proved sensitive to contextual differences even in a young, healthy, and highly functional sample (Schramlová et al., 2024). In a spa rehabilitation setting, the addition of virtual reality to standard care was accompanied by changes in pain and physical mobility, indicating that a supplementary non-pharmacological component can modify outcomes within an already established therapeutic program (Huseynli et al., 2025). Closer to health education in the strict sense, a pilot simulation study showed that rhythm perception influences the chest compression rate achieved during cardiopulmonary resuscitation, an instance of a simple educational cue modifying a measurable performance parameter (Peran et al., 2025), while an analysis of scald injuries caused by water standing in loose garden hoses illustrated the preventive value of awareness of an everyday and entirely avoidable hazard (Uhrová & Böhm, 2021). Taken together, this work supports the premise of the present study, that education delivered by health professionals can produce measurable change, while also indicating that the magnitude of that change depends on the structural conditions under which the recipients live and train.

Physiotherapeutic practice in the Czech Republic has a long tradition of approaching the motor system through the framework of developmental kinesiology, in which postural stabilization is understood as a prerequisite for any phasic movement and ontogenetic motor patterns are used both diagnostically and therapeutically (Kobesova & Kolar, 2014). Extending this holistic logic beyond the motor system to sleep, nutrition, and recovery is a natural, though as yet poorly documented, step.

Three gaps nevertheless remain in this literature, and together they define the problem addressed here. First, the intervention studies summarized above have been conducted almost exclusively in clinical populations or in sedentary and occupationally constrained groups; populations that are already physically active, and for whom the margin for improvement is correspondingly narrower, have seldom been examined, so it is not known whether health education adds anything measurable to an already active lifestyle. Second, education about sleep, light, nutrition, and recovery is usually evaluated as an isolated component, whereas in physiotherapeutic practice it is embedded in a continuing therapeutic relationship; the combined effect of education, habitual physical activity, and individualized physiotherapeutic supervision has not been quantified. Third, it is unclear whether such a combined program influences the objective and subjective domains of health to a similar degree, and whether the competitive context in which a person trains modifies that influence. Resolving these questions matters in practice because physiotherapists are increasingly expected to act as health educators, and because education is relatively inexpensive to deliver but of limited value if recipients are structurally prevented from acting upon it.

The aim of the present study was therefore to evaluate the effects of a six-month combined educational and physical activity program, delivered under physiotherapeutic supervision, on physical fitness, body composition, and self-reported sleep quality and quality of life in two groups of physically active adults differing in their competitive context. A secondary aim was to examine, at baseline, the cross-sectional associations between body composition, physical performance, and self-reported quality of life and sleep. The approach adopted was a prospective two-group pre-post design in which an identical intervention was delivered to a university ice-hockey team and to a recreational fitness community, without a passive control group, as withholding health education from volunteers enrolled in a preventive program was considered ethically inappropriate. Both groups attended the same series of expert-led seminars on sleep and light hygiene, nutrition, stress management, psychosomatic relationships, circadian rhythmicity, and recovery, continued their habitual training, and received individualized physiotherapeutic care throughout the six months. Body composition was determined by direct segmental multi-frequency bioelectrical impedance analysis, physical fitness by a three-item battery combining an anaerobic interval test on an air bike, a passive bar hang, and a one-repetition-maximum deadlift, and the subjective domains by the Pittsburgh Sleep Quality Index and the WHOQOL-BREF. All measurements were repeated after six months under matched conditions, and within-group change, between-group differences, and baseline correlations were then tested statistically.

Materials and Methods

Study design

This was a prospective, non-randomized, two-group intervention study employing a pre-post design. Both groups received an identical intervention; no passive control group was included, as withholding health education from participants who had voluntarily enrolled in a preventive program was considered ethically inappropriate. Baseline assessments were conducted in October 2025, with follow-up assessments performed six months later, in March 2026, at the same facility, at a comparable time of day, and using identical equipment and examiner procedures.

This was a prospective, non-randomized, two-group intervention study with a pre-post design. Both groups received the identical intervention; no passive control group was included, since withholding health education from participants who had volunteered for a preventive program was not considered acceptable. Baseline testing was performed in October 2025 and follow-up testing was performed after six months, in March 2026, at the same facility, at a comparable time of day and using the same equipment and the same examiner.

Participants

Thirty-four participants were enrolled in the study and allocated to two parallel groups of equal size according to the communities from which they were recruited. Group A ($n = 17$) consisted of active members of the university ice-hockey team CTU Engineers Prague. Group B ($n = 17$) consisted of members of the Synergy Club Praha recreational fitness community. The study sample comprised 33 men and 1 woman aged 19-41 years. The inclusion criteria were attendance at the educational seminars, completion of the body composition assessment, completion of the full physical fitness battery, completion of both questionnaires, and participation in both the baseline and follow-up assessments. Participants who failed to complete any of these components were excluded from the final analysis.

All participants were informed about the aims and procedures of the study before enrolment and provided written informed consent for participation and the processing of anonymized data. The study was conducted in accordance with the principles of the Declaration of Helsinki.

The project was implemented as a non-invasive educational and observational program involving routine physical fitness testing, body composition assessment, and validated self-report questionnaires. No pharmacological, invasive, or otherwise burdensome procedures were performed. According to institutional requirements applicable to this type of non-invasive educational project, formal ethics committee approval was not required before the commencement of data collection.

Intervention

The intervention combined an educational component with the participants' habitual physical activity and individualized physiotherapeutic supervision. The educational component consisted of a series of seminars led by qualified specialists in the respective fields, covering sleep and sleep hygiene, light hygiene and the effects of artificial light at night on melatonin secretion, rational nutrition, stress management, psychosomatic relationships, physical activity in relation to circadian rhythmicity, and the principles of active recovery. The stated purpose of the seminars was not to prescribe a weight-loss diet or a training program, but rather to provide participants with a coherent, holistic understanding of the internal and external factors influencing health and to enable them to apply this knowledge in their everyday lives.

Physiotherapeutic supervision was provided throughout the six-month intervention period and was individualized according to each participant's presenting problem. In Group A, care was additionally structured according to the phase of the season. During the preparatory phase, emphasis was placed on preventive care, the treatment of chronic complaints, and the correction of dysfunctional movement patterns, whereas during the competitive phase of the University Ice Hockey League, the priority was the maintenance of performance and the rapid management of acute pain. Management in Group A was coordinated with the team physiotherapist. Conditions treated in both groups included muscle imbalances and overuse syndromes, back pain, peripheral joint injuries, concussion, fractures, and muscle injuries. Treatment incorporated dynamic neuromuscular stabilization, the Ludmila Mojžíšová method, mechanical diagnosis and therapy, spiral stabilization, and acral coactivation therapy. These approaches were supplemented by targeted stabilization exercises, automobilization, soft-tissue techniques, joint mobilization, taping, resistance training, and compensatory exercises, together with physical modalities including laser therapy, therapeutic ultrasound, extracorporeal shockwave therapy, magnetotherapy, electrotherapy, lymphatic drainage, the Super Inductive System, and antigravity treadmill training.

Body composition

Body composition was assessed using the InBody 270 analyzer (InBody Co., Ltd., Republic of Korea), which employs direct segmental multi-frequency bioelectrical impedance analysis with an eight-point tactile electrode system. The device measures the trunk and all four limbs as five independent body segments and applies two frequencies (20 and 100 kHz) to differentiate intracellular from extracellular water. Body composition estimates are derived solely from measured impedance values without the use of demographic prediction equations. Separate thumb and heel electrodes standardize the anatomical starting points of measurement and minimize the influence of skin contact resistance.

A standardized preparation protocol, adapted from the manufacturer's guidelines, was applied before each assessment. Participants were instructed to refrain from physical activity for 3-6 h and from food intake for 2-3 h before measurement, to avoid alcohol and caffeine consumption for 24 h, and to avoid sauna use or showering immediately before the assessment. In addition, they were asked not to apply body lotion to the hands or feet, to maintain adequate hydration on the preceding day, and to empty the bladder immediately before the measurement. Socks, footwear, heavy clothing, and all metal objects were removed prior to testing. Participants then remained standing quietly for 5 min before the assessment.

Measurements were performed with participants wearing underwear only and required approximately 15 s to complete. To ensure optimal electrical conductivity, the palms and soles were cleaned with antibacterial

wipes immediately before testing. The following variables were extracted from the output report: body mass, body mass index (BMI), skeletal muscle mass, skeletal muscle percentage, fat mass, and body fat percentage.

Physical fitness battery

The fitness battery was administered in a fixed order (air bike, passive bar hang, deadlift) at both assessment time points. The air bike is a stationary fan bike in which the pedals and handles are mechanically coupled, such that reciprocal arm action generates substantial torsional loading of the trunk while leg action is comparable to cycling. The exercise engages large muscle groups of both the upper and lower body and is widely used as both a conditioning modality and a test of cardiovascular and metabolic capacity (Schlegel & Křehký, 2020). Participants completed five 30-s intervals separated by 30 s of passive recovery. The maximal output (kcal) achieved during each interval was recorded, and the sum of the five intervals was used as the performance outcome. The passive bar hang was used as a measure of grip endurance, based on evidence that grip strength functions not only as a measure of hand strength but also as a biomarker of general health and vitality (Celis-Morales et al., 2018; Vaishya et al., 2024). Total hang time was recorded in seconds.

The conventional deadlift, performed with the hands positioned outside the knees, was used to determine the one-repetition maximum (1RM) expressed in kilograms. The exercise recruits musculature throughout the body, with predominant activation of the posterior kinetic chain, and is widely used across sports and rehabilitation settings for the development of maximal strength and power.

Questionnaires

Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), a 19-item self-report questionnaire that generates seven component scores (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction), which are summed to produce a global score ranging from 0 to 21. Higher scores indicate poorer sleep quality, and a score >5 is generally considered indicative of poor sleep quality (Buysse et al., 1989).

Quality of life was assessed using the WHOQOL-BREF, the abbreviated 26-item version of the WHOQOL-100. The instrument yields scores in four domains: physical health, psychological health, social relationships, and environment. The WHOQOL-BREF has demonstrated good discriminant validity, content validity, internal consistency, and test-retest reliability (The WHOQOL Group, 1998).

Both questionnaires were completed at baseline and at the six-month follow-up assessment.

Statistical analysis

Data were analyzed using Microsoft Excel 365 (version 16.101.3). Descriptive statistics are presented as means and standard deviations (SD). The normality of the distribution of each baseline and follow-up variable was assessed using the Shapiro-Wilk test. Variables with $p > 0.05$ were considered normally distributed. Within-group differences between baseline and follow-up were evaluated using the paired t-test for normally distributed variables and the Wilcoxon signed-rank test for variables that deviated from normality. Cross-sectional associations at baseline were quantified using Pearson's correlation coefficient. The significance of these associations was tested using linear regression analysis with analysis of variance (ANOVA). Differences in performance between participants with good sleep quality and those with poorer sleep quality were assessed using Welch's t-test for two independent samples with unequal variances. Baseline data were intentionally used for cross-sectional analyses to capture the natural relationships among the measured variables before they could be influenced by the intervention. Statistical significance was set at $\alpha = 0.05$.

Results

All 34 participants completed both assessments. The baseline demographic and body composition characteristics of the two groups are presented in Table 1. The groups were closely comparable at entry, which supports the homogeneity of the sample; Group B was on average approximately three years older and considerably more heterogeneous in age.

Table 1. Baseline characteristics of the sample (mean $\pm$ SD)

Parameter	Group A (n = 17)	Group B (n = 17)	Whole sample (n = 34)
Age (years)	22.8 $\pm$ 1.9	25.9 $\pm$ 6.7	24.3 $\pm$ 5.1
Body mass (kg)	87.2 $\pm$ 11.5	87.9 $\pm$ 11.6	87.5 $\pm$ 11.4
BMI (kg/m ²)	26.3 $\pm$ 3.4	26.5 $\pm$ 2.6	26.4 $\pm$ 3.0
Muscle (%)	49.9 $\pm$ 3.5	49.1 $\pm$ 4.1	49.5 $\pm$ 3.8
Body fat (%)	13.4 $\pm$ 6.2	14.9 $\pm$ 6.5	14.1 $\pm$ 6.3

Group A = university ice-hockey players; Group B = recreationally active adults; BMI = body mass index.

Body composition

Body composition did not change materially over the six months in either group (Table 2). Body mass, muscle percentage and body fat percentage all remained essentially at their baseline values and no variable approached statistical significance. The program therefore had no demonstrable effect on body composition, which was not among its declared objectives.

Table 2. Body composition at baseline and follow-up

Parameter	Group A (n = 17)			Group B (n = 17)		
	Baseline	Follow-up	p	Baseline	Follow-up	p
Body mass (kg)	87.2 ± 11.5	87.3 ± 11.5	0.360	87.9 ± 11.6	87.7 ± 12.0	0.909
Muscle (%)	49.9 ± 3.5	50.3 ± 3.6	0.321	49.1 ± 4.1	49.4 ± 4.6	0.729
Body fat (%)	13.4 ± 6.2	13.4 ± 6.2	0.371	14.9 ± 6.5	14.9 ± 7.0	0.708

Group A = university ice-hockey players; Group B = recreationally active adults. Values are mean ± SD. Wilcoxon signed-rank test.

Physical fitness

Both groups improved their mean performance in all three tests of the fitness battery (Table 3). In Group A the improvement reached statistical significance in every test: passive hang time increased by 6.0 s ($p = 0.044$), the one-repetition-maximum deadlift by 8.0 kg ($p = 0.003$) and total air bike output by 6.7 kcal ($p = 0.004$).

In Group B the improvement was likewise significant in every test: passive hang time increased by 14.3 s ($p = 0.015$), the deadlift by 11.4 kg and air bike output by 11.0 kcal, the latter two highly significantly ($p < 0.001$). The relative gain in hang endurance was thus more than twice as large in Group B (+25.7 %) as in Group A (+10.4 %), whereas the two groups improved comparably in the deadlift (+6.0 % and +9.0 %) and on the air bike (+5.6 % and +9.9 %).

Table 3. Physical fitness at baseline and follow-up

Test	Group A (n = 17)			Group B (n = 17)		
	Baseline	Follow-up	p	Baseline	Follow-up	p
Passive hang (s)	57.8 ± 17.7	63.8 ± 16.4	0.044	55.7 ± 14.3	70.0 ± 17.8	0.015 a
Deadlift 1RM (kg)	134.1 ± 16.1	142.1 ± 14.7	0.003	127.1 ± 28.5	138.5 ± 26.4	< 0.001
Air bike total (kcal)	119.5 ± 10.9	126.2 ± 13.4	0.004	111.1 ± 22.5	122.1 ± 25.5	< 0.001

Values are mean ± SD. 1RM = one-repetition maximum. Passive hang in Group A: Wilcoxon signed-rank test; deadlift and air bike: paired t-test. a Recalculated from the reported means and standard deviations with a t-test for two samples with unequal variances; this is a conservative estimate, because a test for paired samples on positively correlated repeated measures yields a smaller p-value.

Sleep quality and quality of life

The pattern of change in the self-report measures differed between the two groups (Table 4). In Group A the WHOQOL-BREF score rose from 71.4 ± 9.4 % to 74.6 ± 8.4 % and the PSQI global score fell from 3.4 ± 2.2 to 2.8 ± 2.0 points, but neither change reached statistical significance ($p = 0.242$ and $p = 0.134$ respectively). In Group B both instruments changed significantly: the WHOQOL-BREF score rose from 72.9 ± 7.1 % to 83.0 ± 9.0 % ($p = 0.008$) and the PSQI global score fell from 2.8 ± 1.6 to 1.4 ± 1.1 points ($p = 0.005$). Mean PSQI values were below the cut-off of 5 points in both groups at both time points, indicating that the sample as a whole did not report clinically poor sleep at entry.

Table 4. Self-reported quality of life and sleep quality at baseline and follow-up

Instrument	Group A (n = 17)			Group B (n = 17)		
	Baseline	Follow-up	p	Baseline	Follow-up	p
WHOQOL-BREF (%)	71.4 ± 9.4	74.6 ± 8.4	0.242	72.9 ± 7.1	83.0 ± 9.0	0.008
PSQI (points)	3.4 ± 2.2	2.8 ± 2.0	0.134	2.8 ± 1.6	1.4 ± 1.1	0.005

Values are mean ± SD. Higher WHOQOL-BREF scores indicate better quality of life; higher PSQI scores indicate poorer sleep quality. Wilcoxon signed-rank test.

Cross-sectional associations at baseline

The supplementary cross-sectional analyses performed on the baseline data of the whole sample are summarized in Table 5. Only one of the four examined associations was statistically significant: body fat percentage was strongly and inversely associated with passive hang endurance ($r = -0.65$, $p < 0.001$), so that a higher proportion of body fat corresponded to a shorter hang time.

Muscle percentage was not associated with the physical domain of the WHOQOL-BREF ($r = -0.08$, $p = 0.641$), the deadlift one-repetition maximum was not associated with the physical domain ($r = -0.13$, $p = 0.458$), and air bike output was not associated with the psychological domain ($r = -0.10$, $p = 0.555$).

Table 5. Cross-sectional associations at baseline (whole sample, n = 34)

Association	Pearson r	p	Interpretation
Muscle (%) × WHOQOL-BREF physical domain	-0.08	0.641	Non-significant
Deadlift 1RM × WHOQOL-BREF physical domain	-0.13	0.458	Non-significant
Body fat (%) × passive hang time	-0.65	< 0.001	Strong negative
Air bike output × WHOQOL-BREF psychological domain	-0.10	0.555	Non-significant

Significance tested by linear regression with analysis of variance. 1RM = one-repetition maximum.

A further exploratory comparison divided the sample according to self-reported sleep quality. Participants with poorer sleep did not perform worse in any test; mean hang time was 57.7 s versus 56.0 s ($p = 0.719$) and mean deadlift 132.3 kg versus 129.5 kg ($p = 0.710$), while air bike output was significantly higher in the poorer-sleeping subgroup (123.2 versus 110.3 kcal, $p = 0.022$). Given the absence of any plausible mechanism and the narrow range of PSQI scores in this sample, this isolated result is regarded as a chance finding rather than as evidence of a genuine relationship.

Discussion

The principal finding of this study is that a six-month program combining structured health education with habitual physical activity and individualized physiotherapeutic supervision produced measurable gains in muscular and anaerobic performance in both a competitive and a recreationally active group, and produced significant improvements in self-reported sleep quality and quality of life in the recreationally active group, while leaving body composition unchanged. The dissociation between improved fitness and static body composition is the single most consistent pattern in the data and deserves comment first.

This dissociation is entirely consistent with the existing literature. Correa-Rodríguez et al. (2017) showed in 605 young adults that physical activity was consistently associated with fat-free mass but not with fat mass, which was instead predicted by macronutrient intake; total body mass and adiposity are therefore governed principally by diet rather than by activity volume. Štefan et al. (2017) reached a comparable conclusion in university students, adding psychological distress, substance use and self-rated health to the set of determinants of adiposity. Our program contained a nutrition seminar, but its declared purpose was to present a balanced diet supporting performance and health, not to prescribe an energy deficit. In the absence of a targeted nutritional intervention it would have been surprising to observe a change in fat mass, and the stability of body composition should therefore be read not as a failure of the program but as evidence that its effects were expressed in the domains it actually targeted.

The gains in the deadlift and in air bike performance were significant in both groups and of a magnitude that is meaningful in practice, corresponding to approximately 6 % and 9 % of baseline in Group A and to 9 % and 10 % in Group B. It is important to acknowledge that the design does not permit these gains to be attributed to the educational component specifically: both groups continued their habitual training throughout, and in Group A the observation period coincided with the University Ice Hockey League season, which culminated at the very end of the program. Part of the improvement in Group A is therefore almost certainly a training effect of the competitive season. This confounding is a direct consequence of the decision not to withhold the intervention from any participant, and it constrains causal inference accordingly.

The passive hang deserves separate comment because the two groups diverged most clearly in this test. Group B gained 14.3 s (+25.7 %) against 6.0 s (+10.4 %) in Group A, although the groups had entered the study with practically identical hang endurance (55.7 s and 57.8 s). Isometric grip and hang endurance is the parameter of the battery that is least specific to any single sport and most dependent on the ratio of upper-limb strength to body mass; it is therefore the parameter with the greatest scope for improvement in participants whose habitual training does not already load it. Ice-hockey training loads the lower limbs and the trunk far more than sustained grip endurance, whereas the training of the recreational group regularly included hanging and pulling exercises, which plausibly explains the difference. The clinical relevance of this outcome is supported by the fact that grip strength is an established predictor of cardiovascular and all-cause mortality (Celis-Morales et al., 2018) and has been proposed as a vital sign of general health (Vaishya et al., 2024), so that an improvement of this magnitude is not merely a training artefact.

The strong inverse association between body fat percentage and hang endurance at baseline ($r = -0.65$, $p < 0.001$) is the most robust cross-sectional finding. It has a straightforward biomechanical interpretation, since the passive hang is a test of the capacity of the grip to support body mass, and any increase in fat mass increases the load without contributing to the force-generating capacity of the forearm musculature. This is consistent with the broader literature identifying grip strength as an index of general health (Celis-Morales et al., 2018; Vaishya et al., 2024) and suggests that a body-mass-normalized expression of hang endurance may be a more informative preventive screening measure than the absolute time.

By contrast, none of the associations between the objective parameters and the WHOQOL-BREF domains reached significance. This differs from findings in older and clinical populations, in which handgrip strength correlates with health-related quality of life (Halaweh, 2020) and low skeletal muscle mass is associated with poorer global and physical-functioning scores (Hanna et al., 2022). The discrepancy is most plausibly explained by restriction of range. Our participants were young, physically active and reported high quality of life at entry (mean WHOQOL-BREF above 71 % in both groups), so both the predictor and the outcome varied within a narrow band in which a linear association is difficult to detect. Associations of this kind appear to emerge where muscle function has declined far enough to limit everyday activity, which was not the case here.

The divergent questionnaire results between the groups are the most interesting outcome of the intervention. Group B improved significantly in both quality of life (+10.1 percentage points) and sleep quality (-1.4 PSQI points), whereas Group A improved in the same direction without reaching significance. Two explanations are plausible and not mutually exclusive. First, a ceiling effect: both groups reported good sleep at entry (mean PSQI 3.4 and 2.8, well below the cut-off of 5 points), leaving limited room for improvement, and this restriction was compounded in Group A by the smaller number of participants above the threshold. Second, competing demands: the observation period coincided with both the competitive season and the academic semester for Group A, and the combination of travel, evening fixtures, academic deadlines and training load is precisely the constellation that has been shown to prevent athletes from obtaining the sleep they require (Watson, 2017; Fullagar et al., 2015). Educational content about sleep hygiene can be understood and accepted while remaining impossible to implement, and the discrepancy between the two groups may reflect the difference between knowing what to do and being in a position to do it.

This interpretation has a practical corollary. If the barrier to improved sleep in competitive athletes is structural rather than informational, then education alone is unlikely to be sufficient and should be complemented by measures acting on the schedule itself, such as the planning of training and travel around sleep opportunity, the strategic use of daytime naps, and limits on evening exposure to short-wavelength light. The magnitude of what is at stake is well documented: habitual short sleep is associated with increased all-cause mortality and with cardiovascular, metabolic and psychiatric morbidity (Shah et al., 2025), and the mechanisms implicated include circadian gene expression, glucose and lipid metabolism, inflammatory signaling and the gut microbiome (Hong et al., 2025). In ice hockey specifically, where match play depletes muscle glycogen to the point of impairing high-intensity skating in the final stages of a game (Vigh-Larsen & Mohr, 2024), recovery quality is not a peripheral concern but a determinant of performance.

More broadly, the results support the view that the physiotherapist can function as an initiator of lifestyle change rather than solely as a provider of treatment. This is consistent with the tradition of Czech rehabilitation, in which the motor system is approached through the framework of developmental kinesiology and postural function is understood as the substrate of all phasic movement (Kobesova & Kolar, 2014), and with the evidence base establishing exercise as a therapeutic agent across a wide spectrum of chronic disease (Pedersen & Saltin, 2015). Extending that logic to sleep, light exposure, nutrition and recovery places the physiotherapist in the role of a health educator with sustained, repeated contact with the client, which is a position few other health professionals occupy.

Limitations

Several limitations must be acknowledged. The study was not randomized and did not include a passive control group, so the observed changes cannot be attributed to the intervention with confidence; secular change, seasonal training effects and regression to the mean all remain plausible alternative explanations. The sample was small ($n = 34$), was drawn from two convenience-recruited communities and was almost exclusively male (33 men, 1 woman), which precludes any analysis by sex and limits generalizability. Training load and dietary intake were not quantified, so the contribution of the educational component cannot be separated from that of habitual training. Adherence to the educational recommendations was not measured, and both sleep quality and quality of life were assessed by self-report, which is susceptible to expectancy effects in an unblinded design; the improvement in the WHOQOL-BREF in Group B may therefore partly reflect the participants' awareness of taking part in a health program. Effect sizes and confidence intervals were not calculated, so the practical magnitude of the changes cannot be formally quantified, and the significance of the change in passive hang endurance in Group B had to be estimated from the reported summary statistics rather than from a test for paired samples.

Conclusions

A six-month program combining expert-led education on sleep, light hygiene, nutrition, stress and recovery with habitual physical activity and individualized physiotherapeutic supervision was associated with significant improvements in maximal strength and anaerobic performance in both university ice-hockey players and recreationally active adults, and with significant improvements in self-reported sleep quality and quality of life in the recreationally active group only. Body composition remained unchanged in both groups, in line with evidence that adiposity responds primarily to nutritional rather than to activity-based intervention. At baseline, body fat percentage was strongly and inversely associated with passive hang endurance, whereas no association

was found between objective performance parameters and the corresponding WHOQOL-BREF domains in this young, active and high-functioning sample.

For practice, these findings suggest that health education delivered by a physiotherapist can act as a catalyst for change in the subjective domains of sleep and quality of life among recreationally active adults, but that in competitive athletes the constraints of the season and of concurrent academic demands may prevent that knowledge from being translated into behavior. In such populations, education should be combined with structural measures acting on the training and travel schedule itself. Randomized studies with a control group, objective monitoring of sleep and training load, larger and sex-balanced samples and the reporting of effect sizes are required before these conclusions can be regarded as established.

Ethics

All participants took part in the study voluntarily and signed a written informed consent form for their inclusion in the study sample; they were free to withdraw from the study at any time and without giving a reason. The entire study was conducted in accordance with the Declaration of Helsinki.

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Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used Claude Opus 5.0 (Anthropic) in order to assist with language editing, structuring of the manuscript and formatting of the reference list. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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