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FACTORS ASSOCIATED WITH LOW BACK OVERUSE INJURIES IN SPORTS SCIENCE STUDENTS – A PROSPECTIVE STUDY

DEJAVNIKI BOLEČIN V SPODNJEM DELU HRBTA PRI ŠTUDENTIH PROGRAMOV ŠPORTNIH SMERI – PROSPEKTIVNA ŠTUDIJA

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ABSTRACT

Keywords:
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Background: Sports science students (SPS) are more likely to be affected by low back pain (LBP) compared to the young, physically active population. The aim of this prospective study was to evaluate potential risk factors for LBP in the population of SPS.

Methods: Before the beginning of the study the participants (n=54) performed initial physical performance testing and gave blood samples. Then they were followed up for 10 weeks. The observed outcome was LBP occurrence. The presence of the observed outcome was recorded using the Oslo Sports Trauma Research Centre Overuse Injury Questionnaire weekly. The association between LBP and potential explanatory factors - potential overtraining parameters (e.g. ferritin and iron levels, amount of sleep) and motor ability parameters (e.g. muscle strength, vertical jump) - was assessed using multiple binary logistic regression.

Results: During the 10 week prospective follow-up LBP was the most common problem affecting 13% of students. From the group of explanatory factors for LBP only two were included in the final model as statistically significant: low ferritin level (OR=8.70, p=0.008), and history of previous LBP (OR=8.69; p=0.006) made students more likely experience new LBP problems.

Conclusions: The SPS that are more at risk of experiencing LBP are those with a history of LBP and those with low ferritin level. Awareness should be raised among students about the importance of comprehensive LBP prevention (preventive exercise, preventive medical check up including blood test).

IZVLEČEK

Ključne besede:
študenti
bolečine v križu
raven feritina
mišična moč
preventiva

Uvod: *Študenti programov športne smeri (SPS) so bolj dovzetni za bolečine v spodnjem delu hrbta (BSH) kot mlada, telesno dejavna populacija. Namen prospektivne študije je bil oceniti potencialne dejavnike tveganja za BSH med populacijo SPS.*

Metode: *Pred začetkom raziskave so udeleženci (n = 54) opravili testiranje telesne zmogljivosti in oddali vzorce krvi. Nato smo jih spremljali 10 tednov. Opazovan izid je bila bolečina v spodnjem delu hrbta (BSH). Pojavnost opazovanega izida je bila beležena z vprašalnikom Oslo Sports Trauma Research Centre Overuse Injury Questionnaire na tedenski bazi. Povezanost med BSH in možnimi pojasnjevalnimi dejavniki - morebitnimi dejavniki pretreniranosti (npr. raven železa in feritina, količina spanca) in dejavniki gibalnih sposobnosti (npr. mišična moč, vertikalni skok) - smo ocenili z uporabo multiple binarne logistične regresije.*

Rezultati: *Tekom 10-tedenskega prospektivnega spremljanja je bila BSH najpogostejša težava, ki je prizadela 13 % študentov. Iz skupine pojasnjevalnih dejavnikov za BSH sta bila v končni model vključena samo dva kot statistično pomembna: nizka raven feritina (OR = 8,70; p = 0,008) in anamneza predhodne BSH (OR = 8,69; p = 0,006) sta pomenila večjo verjetnost pojava BSH.*

Zaključki: *SPS, pri katerih obstaja večje tveganje za BSH, so tisti z anamnezo BSH in tisti z nizko ravnjo feritina. Študente je treba ozaveščati glede pomembnosti celovite preventive BSH (preventivna vadba, preventivni zdravstveni pregledi vključno s preiskavami krvi).*

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1 INTRODUCTION

Students in sports science faculties (including future physical education teachers, kinesiologists and coaches) (SPS) are more likely to be affected by injuries compared to the young, physically active population (1) due to higher physical load. Injuries interfere with the fulfilment of study responsibilities, prolong study time, and impact graduation rates and students' health (2). After graduation, these occupations place high demands on physical fitness and performance. Injuries that occur at a young age during university may increase susceptibility to injury later in the career (3). Many injuries can lead to limitations in work ability, reduction in years of service, change of occupation, and disability (4). Considering these facts, exploring potential risk factors for injury in this population is an important public health issue.

The incidence of injury among SPS is 11.7/1,000 hours of physical activity (1). Lower extremity injuries are the most common (1, 4). Most injuries are acute, non-contact, medical attention is required in 80% of cases, and approximately half of the injuries result in absence from class and training and/or competition for at least one week or longer (2). Apart from acute injuries, SPS may also suffer from chronic overuse injuries, where low back overuse injuries are quite common, with low back pain (LBP) being the most common symptom. The incidence of LBP in the general population is estimated to be 15% with the point prevalence of 30% (5).The annual LBP prevalence in young adults ranges from 32.4% (6) to 42.4% (7). The prevalence of LBP in young athletes was shown to have a point prevalence ranging from 10% to 67%, a one-year prevalence ranging from 17% to 94% and a life-time prevalence ranging from 33% to 84% (8).

Previous studies mainly analysed non-modifiable risk factors (e.g., sex, age, previous injuries and general health) (3, 9). Among the various modifiable risk factors, postural stability, flexibility and muscle strength have been investigated, and it appears that some physical performance tests may be important for injury prediction. Additional potential causes of LBP in young adults were marital status, strenuous exercise, job satisfaction, monotony, stress, daily number of studying hours and family history of spine problems ($p<0.05$), all associated with LBP (7). Because first-year SPS are exposed to a high physical activity load determined by the curriculum, it is surprising that previous studies have not included potential overtraining parameters (e.g. training load, ferritin) in injury prediction models.

An increased number of hours of physical activity in the young active population and consequently higher physical load (10) may lead to fatigue and/or overtraining (11, 12), resulting in a decrease in athletic performance (13). Increased load can affect biochemical indicators of overtraining (14). In addition to students' study commitments, the development of overtraining is also influenced by extracurricular commitments and lifestyle: amount of sleep, diet, habits (14).

Aiming to identify risk factors for overuse injuries among SPS, the objective was to evaluate the relationship between LBP occurrence and the potential overtraining parameters (e.g. ferritin and iron levels, amount of sleep) and motor ability parameters (e.g. muscle strength, vertical jump).

2 MATERIAL AND METHODS

2.1 Study design, setting and time frame

The present study was designed as a prospective study that investigated different musculo-skeletal problems in the group of students at the Faculty of Sports of the University of Ljubljana in the academic year 2019/2020. The present paper is only reporting findings about LBP problems.

2.2 Study population and inclusion criteria

A total generation of 160 students of the first academic year was invited to participate in the study. The main inclusion criteria were: age ≥18 years and no major injuries upon entry into the study (injuries that would demand more than 4 weeks to return to physical activity).

2.3 Study course, study instruments and procedures

2.3.1 Study course

At the start of the academic year study participants underwent the battery of physical performance testing, and blood samples were taken for subsequent analysis. The follow-up took place over 10 weeks during the first study semester.

2.3.2 Biochemical analyses

Blood samples included potential biochemical factors (indicators of overtraining): iron, ferritin and haemoglobin. The haemoglobin [g/L] was analysed from EDTA-blood (Vacutube, Burnik, Slovenia) with automated haematology analyser ABX Pentra XL 80 (Horiba, Ltd., Japan. Serum iron [µmol/L] and ferritin [µg/L] were analysed on a Dimension EXL 200 integrated clinical chemistry and immunoassay analyser (Siemens Healthineers, Germany) with IRON, FERR-ferritin (H-Modul) reagents respectively (all Siemens Healthineers, Newark, USA). Ferritin values were afterwards grouped into normal (≥35 µg/L) and low values (0-34 µg/L), which formed a new categorical variable "ferritin level": 0 = normal level, 1 = low level. Samples were collected in the morning following overnight fasting. They were drawn from the antecubital vein using a 21-gauge needle (40 mm) into 2.5 mL and 10 mL BD Vacutainer ® vacuum serum tubes with silica particles coating (Becton, Dickinson and Company, Vacutainer System Europe, Heidelberg, Germany). The blood samples were analysed in 4 hours after the blood drawing. Serum tubes were centrifuged on 1,500 g for 10 minutes and the aliquots of serum were stored at -30° C for a maximum of one month. For all laboratory findings, the lower the values, the greater the possibility of LBP.

2.3.3 Physical performance

The physical performance testing included vertical jump, balance and knee, ankle and trunk isometric strength tests.

For the verical jump testing a bilateral force plate was used (Kistler, model 9260AA6, Winterthur, Switzerland). After the warm up/familiarisation the subjects performed 3 maximal countermovement jumps and 3 maximal squat jumps with 30 sec rest between jumps. The main outcome measures were jump height (cm) and mean power (P) normalised to body weight (W/kg).

For assessment of balance the body sway test was applied during a single leg stand on a force platform¸with hands on the hips. The participants were asked to look at a fixed point approximately 4 m in front of the participant and at eye level. They performed three 30-second repetitions for each leg, with 60-second breaks between repetitions. The data that we used were mean CoP velocity [total, anterior–posterior (AP), and medial–lateral (ML)], CoP amplitude (AP and ML), and CoP frequency.

The main outcome measure for strength testing was force in Newtons or torque in Newton-meters. Knee strength was assessed using a Dynamometer S2P, Science to Practice Ltd, Ljubljana, Slovenia. Measurement was performed in seated position with proper fixation and the mechanical axis of the dynamometer aligned with the subject's knee. After warm-up and familiarisation the subjects performed three maximal voluntary contractions (MVC) three seconds long with 60-sec rest between repetition for knee flexion (KF) and extension (KE). Assessment of trunk strength was done by having the subjects standing next to the dynamometer firmly fixed across the pelvis with a belt. Arms were positioned on the shoulder or were hanging free. The instruction given was to gradually increase the force to the maximum and the keep it for 3-5 sec. The lever arm was recorded for each measurement. Assessment of ankle strength was done by having the subject's shins tightly fixed on the dynamometer, so the feet were placed and firmly fixed with a strap on a firm plate adjusted on the torque sensor. The ankle was in neutral position and the axis of the dynamometer was aligned to the medial malleolus. Finaly, the subjects were asked to do plantar (PF) and dorsal flexion (DF).

For all tests, the higher the value, the lower the chance of LBP.

2.3.4 Reporting of musculoskeletal system problems and overuse injuries

For the follow-up and reporting of musculoskeletal system problems and overuse injuries, the Oslo Sports Trauma Research Centre Overuse Injury Questionnaire (OSTRC-O), established as a reliable (Cronbach's α=0.91) and valid instrument (PCA results: factor weighting 0.86-0.91), was used (15). The OSTRC-O consists of four questions that relate to participation, modification of training volume, performance and symptoms, which are repeated for each area of interest (15). For the first and fourth questions, which have 4 options each, the answers are scored 0-8-17-25, and for the second and third questions, which have 5 options each, the answers are scored 0-6-13-19-25. The answer to each question is scored with min=0 and max=25. These scores were afterwards summed and were grouped into no injury group (score equals 0) and injury group (score >0), which formed a new categorical variable "injury status": 0=no injury, 1=injury. The instrument was administered to participants on a weekly basis.

2.3.5 Other data collection

SPS training and pedagogical workload at the faculty was self-reported in hours using questionnaries on a weekly basis. Data on sleep were self-reported in terms of quantity (average sleep hours in the last week) and quality (as VAS; values 0-10) also on a weekly basis. Sleep hours were additionally grouped into two groups forming a new variable "sleep deficit": 0 = no (≥7 hours), 1=yes (<7 hours).

Participants were also asked to provide information on LBP and knee injury, both in the past year prior the study (0=no, 1=yes).

2.4 Observed phenomena

For the purpose of this study, it was only observed whether the participant had lower back problems or not (the sum of the items in the OSTRC-O was equal to 0), and as a result the variable "the presence of LBP in the observed period" was created (0=no, 1=yes) as the observed outcome.

As explanatory factors biochemical factors, physical performance factors, workload factors, sleep and wellbeing factors, and history of pain were considered. Sex and body mass index were used as confounders.

2.5 Methods of analysis

First, statistical description of the variables was carried out using standard descriptive statistical methods.

Afterwards, a univariate logistic regression was performed to ascertain the effects of different predictors on the likelihood that students will experience LBP during the 10-weeks of winter semester at the sports science faculty.

Finally, multiple stepwise logistic regression (Forward Selection Likelihood Ratio method) was performed to identify the best model to explain the relationship between LBP and potential factors. Only factors with p-value in the univariate analysis up to p<0.050 were included in the multivariate analysis.

The analysis was performed using IBM SPSS 25 software (SPSS Inc., Armonk, NY, USA) and the overall level of statistical significance was set at p<0.050.

3 RESULTS

3.1 Basic characteristics of participants

Out of 160 invited students 69 responded to the invitation, of which 54 completed the full follow-up. Basic characteristics are presented in Table 1. During the 10-week prospective follow-up the prevalence of LBP was between 6% and 24% (13% on average across the 10-week period) without sex differences in the prevalence of LBP (p=0.211).

Table 1. Basic characteristics of participants of the study of factors associated with LBP in sports science students of Ljubljana University Faculty of Sports; n=54.

Characteristic	Category	Count (%)	Mean±SD
Sex	Females	25 (46.3%)	
	Males	29 (53.7%)	
Age (years)			19.1±0.6
BMI (kg/m2)			22.4±2.2
BMI	Normal weight	47 (87.0%)	
	Overweight	7 (13.0%)	

Legend: LBP=low back pain; SD=standard deviation; BMI=body mass index

3.2 Description of explanatory factors

Basic characteristics of explanatory factors for LBP are presented in Table 2.

3.3 Results of univariate analysis

The univariate logistic regression model has shown some statisticaly significant predictors of LBP (Table 3).

Table 2. Basic characteristics of explanatory factors for LBP in sports science students of Ljubljana University Faculty of Sports; n=54.

Group of factors	Factor	Category	Count (%)	Mean±SD
BIOCHEMICAL FACTORS				
	Iron [µmol/L]			18.5±6.6
	Ferritin [µg/L]			51.6±29.1
	Ferritin level	Normal	37 (68.5%)	
		Low	17 (31.5%)	
	Haemoglobin [g/L]			141.7±14.7
PHYSICAL FITNESS FACTORS				
Balance	Overall PSV left [mm/s]			38.4±9.1
	Overall PSV right [mm/s]			37.2±8.6
	AP PSV left [mm/s]			23.8±5.8
	AP PSV right [mm/s]			23.2±5.8
	ML PSV left [mm/s]			25.6±6.4
	ML PSV right [mm/s]			24.6±5.8
Vertical jump	SJ height [cm]			27.0.0±5.0
	SJ power [W/kg]			48.1±7.4
	CMJ height [cm]			30.0±7.0
	CMJ power [W/kg]			47.1±7.7
Trunk strength	Extension [Nm]			229.1±98.1
	Flexion [Nm]			181.4±79.5
	Lateral flexion left [Nm]			162.9±70.3
	Lateral flexion right [Nm]			161.3±75.0
Knee strength	Extension left [N]			193.8±55.1
	Extension right [N]			184.1±54.9
	Flexion left [N]			106.9±32.6
	Flexion right [N]			112.4±35.7

Group of factors	Factor	Category	Count (%)	Mean±SD
Ankle strength	Plantar flexion [N]			250.5±83.1
	Plantar flexion left [N]			126.5±43.2
	Plantar flexion right [N]			124.9±41.2
	Dorsal flexion [N]			75.1±28.5
	Dorsal flexion left [N]			34.3±15.0
	Dorsal flexion right [N]			41.2±13.9
WORKLOAD AND SLEEP FACTORS				
	Training (h)			8.9±5.3
	Practical courses (h)			8.0±3.0
	Sleep quantity (h)			6.9±0.7
	Sleep deficit	No	24 (44.5%)	
		Yes	30 (55.6%)	
	Sleep quality (VAS)			6.3±1.5
PREVIOUS INJURY FACTORS				
	Previous LBP	No	35 (64.8%)	
		Yes	19 (35.2%)	
	Previous knee injury	No	47 (87.0%)	
		Yes	7 (13.0%)	

Legend: LBP=low back pain; SD=standard deviation; PSV=postural sway velocity; AP=anterior-posterior; ML=medial-lateral; SJ=squat jump; CMJ=countermovement jump; VAS=visual analogue scale

Table 3. Results of univariate analysis of relationship between LBP and different explanatory factors in sports science students of Ljubljana University Faculty of Sports; n=54.

Group of factors	Factor	Category	OR (95% CI for OR)	p
BIOCHEMICAL FACTORS	Iron [µmol/L]		0.98 (0.91-1.08)	0.764
	Ferritin [µg/L]		0.99 (0.97-1.01)	0.282
	Ferritin level	Normal	1.00	0.043
		Low	3.50 (1.04-11.77)	
	Haemoglobin [g/L]		0.98 (0.94-1.02)	0.232
PHYSICAL FITNESS FACTORS				
Balance	Overall PSV left [mm/s]		0.99 (0.94-1.06)	0.928
	Overall PSV right [mm/s]		0.98 (0.92-1.05)	0.611
	AP PSV left [mm/s]		1.01 (0.92-1.12)	0.779
	AP PSV right [mm/s]		0.98 (0.89-1.08)	0.684
	ML PSV left [mm/s]		0.98 (0.89-1.07)	0.655
	ML PSV right [mm/s]		0.97 (0.87-1.07)	0.549
Vertical jump	SJ height [cm]		0.00 (0.00-2.19)	0.068
	SJ power [W/kg]		0.93 (0.85-1.01)	0.098
	CMJ height [cm]		0.00 (0.00-1.16)	0.054
	CMJ power [W/kg]		0.92 (0.84-0.99)	0.044
Trunk strength	Extension [Nm]		0.99 (0.99-1.00)	0.059
	Flexion [Nm]		0.99 (0.98-0.99)	0.030
	Lateral flexion left [Nm]		0.99 (0.99-1.01)	0.451
	Lateral flexion right [Nm]		0.99 (0.99-1.00)	0.170
Knee strength	Extension left [N]		0.99 (0.98-1.00)	0.096
	Extension right [N]		0.99 (0.98-1.00)	0.103
	Flexion left [N]		0.98 (0.96-0.99)	0.026
	Flexion right [N]		0.98 (0.96-1.00)	0.045

Group of factors	Factor	Category	OR (95% CI for OR)	p
Ankle strength	Plantar flexion [N]		0.99 (0.98-1.02)	0.687
	Plantar flexion left [N]		0.99 (0.96-1.04)	0.769
	Plantar flexion right [N]		0.99 (0.95-1.04)	0.724
	Dorsal flexion [N]		0.99 (0.99-1.00)	0.093
	Dorsal flexion left [N]		0.99 (0.98-1.00)	0.115
	Dorsal flexion right [N]		0.99 (0.97-1.00)	0.086
WORKLOAD AND SLEEP FACTORS				
	Training (h)		0.99 (0.98-1.01)	0.842
	Practical courses (h)		1.02 (0.99-1.04)	0.144
	Sleep quantity (h)		0.57 (0.23-1.41)	0.221
	Sleep deficit	No	1.00	0.087
		Yes	2.91 (0.86-9.86)	
	Sleep quality (VAS)		0.77 (0.51-1.16)	0.218
PREVIOUS INJURY FACTORS				
	Previous LBP	No	1.00	0.007
		Yes	5.50 (1.61-18.84)	
	Previous knee injury	No	1.00	0.775
		Yes	0.78 (0.14-4.45)	
CONFOUNDING FACTORS				
	Sex	Males	1.00	0.127
		Females	2.47 (0.77-7.88)	
	BMI	Overweight	1.00	0.275
		Normal weight	0.29 (0.03-2.65)	

Legend: LBP=low back pain; OR=odds ratio; CI=confidence interval; PSV=postural sway velocity; AP=anterior-posterior; ML=medial-lateral; SJ=squat jump; CMJ=countermovement jump; VAS=visual analogue scale

Presence of low ferritin level and the experience of LBP in the past year prior to the study showed a statistically significant positive association, while all statistically important physical fitness indicators (countermovement jump power, trunk flexion strength, and left and right knee flexion strengths) expressed a statistically significant negative association with the observed outcome.

Table 4. Results of multivariate analysis of relationship between LBP and different explanatory factors in sports science students adjusted for BMI and sex; n=54.

Factor	Category	OR (95% CI for OR)	p
Ferritin level	Normal	1.00	0.008
	Low	8.70 (1.78-42.60)	
Previous LBP	No	1.00	0.006
	Yes	8.69 (1.94-38.98)	

Legend: LBP=low back pain; OR=odds ratio; CI=confidence interval.

3.4 Results of multivariate analysis

The multivariate logistic regression with forward selection likelihood ratio model (Table 4) was statistically significant ($p < 0.001$). The model explained 37.9% (Nagelkerke R2) of the variance in LBP and correctly classified 94.4% of cases. Students with low ferritin level (95% CI for OR 1.78-42.60), and history of previous LBP (95% CI for OR.94-38.98) were more likely to experience new LBP problems when controlled for sex and BMI categories.

4 DISCUSSION

LBP was the most common overuse problem in SPS during the first 10 weeks of study and accounted for an average of 13% of all musculo-skeletal disorders (MSD). We showed that LBP was associated with low ferritin level and a history of LBP.

All previous studies that reported the prevalence of LBP in SPS (16-21) were retrospective cross-sectional studies and reported much higher prevalence, ranging from 15% to 76%. However, the study with the largest sample (19) showed that 15% of physical education students reported LBP, which was strongly associated with fatigue. This is the only study whose results are comparable to those of our study, as all other studies showed a much higher prevalence of LBP. We must emphasise the importance of tracking injuries prospectively on a weekly basis (as was the case in our study), as we believe this provides more reliable data. Even in our sample, the reported prevalence of previous LBP was much higher (35%) than that calculated from the prospective follow-up (15%). The most comparable study (21) showed that the six-month prevalence (each time data was collected cross-sectionally) was 61%, but in a follow-up of the 74 students from the original group after the end of the first semester, the reported prevalence was 18%, which is consistent with our data. Among the different types of physical activity and sports, gymnastics has been identified as a high-risk sport for LBP (22) and since it is part of the mandatory curriculum for Slovenian SPS, it may partly explain the prevalence of LBP.

Previous history of LBP was a strong risk factor for a future episode of LBP in our study. This is consistent with a study (23) that showed that recurrence of LBP is very common, with more than two-thirds of individuals having a recurrence within 12 months of recovery. A systematic review (24) reported that a history of LBP is the most consistent risk factor for transition to LBP after a pain-free baseline.

We have also shown that low ferritin level is associated with LBP occurrence in SPS over a 10-week period, which is in line with the findings of the clinical study (25) which showed that serum ferritin was negatively correlated with the degree of intervertebral disc degeneration and can be used for its severity prediction. A case control study (26) reported that serum iron levels were significantly different in patients with LBP compared to healthy individuals. In patients with LBP a strong link with iron level and severity of LBP was also reported (26), showing that low iron level and high inflammatory indicators were not only connected with the prevalence of LBP but also with its severity. The underlying mechanism for association between LBP and ferritin level could be via induction of oxidative stress and ferroptosis in endplate chondrocytes (27). High physical demands can lead to excessive stress and inflammatory reaction (28) and thus lower iron and ferritin. Since oxidative stress and inflammatory reaction are present in overtraining syndrome (29), both low ferritin level and LBP in our study could also be attributed to possible underlying overtraining. Iron status and its impact on LBP remains controversial in literature, and well planned randomised controlled trials are needed to fully understand this association. As LBP is one of the most common musculoskeletal disorders in the young physically active population, and iron status blood indicators are often used for health status follow-up, the influence of iron disorder and LBP could therefore represent added value in the diagnostic and therapeutic area.

Maximal trunk flexor strength was identified as a significant risk factor on the univariate level for the development of LBP. A cross-sectional study (30) showed that trunk isometric strength (flexion and/or extension) and its ratios have low predictive validity for differentiation in relation to LBP history, but it seems that these variables, when used in a prospective manner, may have some predictive validity for LBP, which should be investigated in the future. For such purposes, maximal isometric trunk strength should be measured along with trunk muscle endurance, as a study (31) using EMG (Electormyography) showed that young tennis players with LBP are expected to have lower trunk extensor activation, fewer co-contraction patterns and lower abdominal endurance. A cross-sectional study on physiotherapy students also showed that LBP was the main MSD and was connected to poor trunk flexibility (32). Maximal knee flexor strength both right and left side was also recognised as a significant risk factor on a univariate level for LBP. A study on a group of soccer players also showed a statistical difference in maximal strength of knee flexors on both sides in the group with LBP (33). On the other hand meta-analysis reported no significant difference in knee flexor strength in patients with LBP compared to the healthy population (34). The limitations and different survey results are due to the use of various dynamometers and protocols which does not allow a direct comparison between studies.

The main limitations of our study are the small sample size and the short prospective follow-up period precluding gender-specific analysis. Because of the SARS-Cov-2 pandemic and lockdown, we were able to follow up students only during the winter semester (ten weeks) and it prevented us from repeating some tests as planned before. However, the prospective data are one of the strengths of our study, because students' health problems were recorded weekly, which allowed us to track workload and LBP occurrence simultaneously. One could dispute the small numbers of participants in the study. However, the most comparable study also had such a small number of participants. Participation in the study was time consuming and an additional burden for SPS, which is one of the reasons they decided not to participate.

The type of LBP might be important (e.g., different patho-anatomy and biopsychosocial prognosis in spondylolysis versus degenerative disc problems), so future studies should also make this distinction. Iron status and its impact on LBP remains controversial in literature and well planned randomised controlled trials are needed to fully understand this association. We must also take into account that our model has explained only about 38% of the LBP occurrence, and that there may be other factors that could have caused the LBP that were not included in our study (e.g. psycho-social factors, family predisposition).

The study's strength is that it provides a novel approach in LBP in SPS in the form of a prospective follow-up, and includes determinants that have rarely been studied before such as blood ferritin level.

The results of the study are of significant importance and use in occupational and sports medicine in terms of preventive medical check-up content and developing strategies to prevent LBP in the active population.

Further research in this field should be upgraded by applying preventive strategies in active young adults and athletes including follow-up to evaluate the effect of the measures.

5 CONCLUSION

First-year SPS are exposed to high workloads due to concurrent training and faculty curriculum. Students most at risk are those with a history of LBP and low ferritin level. Our findings could be of interest for sports medicine physicians to better implement preventive strategies to mitigate the risk of LBP. This means that students with a history of LBP and concomitant low ferritin levels could be prompted to do more preventive exercise (e.g. core stability training) and additional nutritional consultation with sports dietitians to improve the iron status. Future studies including longer follow-up, larger samples and with implementation of such clinical approach are needed.

CONFLICTS OF INTEREST

The authors declare that no conflicts of interest exist.

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ETHICAL APPROVAL

The study was approved by the Committee of Medical Ethics at the Ministry of Health in Ljubljana (No. 0120-492/2019). Prior to inclusion all students were informed about the methods, procedures and potential risk during the study and gave their written consent.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study can be obtained upon request from the corresponding author.

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