Exercise Physiology

Risk factors associated with musculoskeletal symptoms in military high school students: a cohort study

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Abstract - Aim To evaluate the association between the occurrence of musculoskeletal symptoms and potential risk factors in military high school students. **Methods:** Participants were Brazilian military high school students. They were evaluated in two consecutive days: Day 1: anamnesis and physical fitness tests; Day 2: Cooper 12-min run test. A follow-up of 16 months of the sample was performed to register musculoskeletal symptoms. A Proportion Comparison Test was performed to evaluate if there was a significant difference between the number of musculoskeletal complaints among regions of trunk, lower limbs and upper limbs. Results of the baseline evaluation (age, body composition and physical fitness) were presented as mean and standard deviation. A 2x2 table was developed with the sociodemographic, lifestyle and previous symptoms variables at the baseline evaluation. Finally, a bivariate logistic regression analysis was used to evaluate the association/interaction between independent variables and musculoskeletal symptoms. **Results:** A total of 86 students (16.0 ± 1.0 years, 22.4 ± 3.2 of body mass index and 15.7 ± 6.6% body fat) were included. Proportion Comparison Test showed no difference between knee and shoulders, hip or thigh and neck (P = 0.21; P = 0.10; and P = 0.10, respectively). Bivariate analysis showed association among the age and parent's occupation and any musculoskeletal symptom in any body region (OR = 0.50, 95%CI = 0.26-0.92; OR = 4.68, 95%CI = 1.70-12.82, respectively). **Conclusion:** Age is a protective factor for musculoskeletal symptoms in any region of the body in high school military students, with older students having less chance of symptoms.

Keywords: military, athletic injuries, adolescent.

Introduction

Symptoms of musculoskeletal pain or discomfort are among the main causes of disability[1]. They are common among teenagers, especially in the lower limbs and spine[2]. Although they may not lead to a continuity of these symptoms in adulthood, they can compromise the performance of physical exercises[3], being a risk factor for chronic pain in adulthood[4]. The most cited causes are: low levels of physical conditioning, lack of flexibility, muscle weakness, overweight, muscle fatigue, previous injury, high training loads and others[5,6].

There is strong evidence that physical activity is associated with several health benefits, such as beneficial effects adiposity, musculoskeletal health and fitness, and several components of cardiovascular health. In addition, exercises can promote beneficial effects on adiposity levels in those with a normal body mass, on blood pressure in normotensive youth, on plasma lipid and lipoproteins levels, on non-traditional cardiovascular risk factors, and on several components of mental health[7].

In military schools, there is a routine with a greater frequency of physical exercises provided for in the school schedule in which students perform, for at least three years, a daily routine of typically military activities, such as marching, united order, military physical training and the practice of various sports. Thus, adolescents seem to have a healthier lifestyle, with better indicators of body composition, general physical conditioning and neuromuscular control[8-10]. In many military training courses, students are submitted to large amount of physical training. Consequently, the body regions most affected by musculoskeletal injuries are the trunk and the lower limbs[11,12].

Although several studies have evaluated the potential risk factors for musculoskeletal symptoms in military personnel[13-16], the risk factors for symptoms in high-school students (age between 15 and 18 years) are unknown. Among military personnel, the risk factors pointed out in the literature are: previous injury[17], body mass index (BMI)[6], age[18], performance in running tests[19], and socioeconomical factors (parent's occupational group, parents' educational level and urbanization level of the place of residence) and others (previous sports practice, previous strength training in lower limbs, previous sports competitions and Aerobic training ≥3x/week)[6]. The main impact of injuries is the removal of students from course activities, in addition to the cost of health services. The knowledge of those factors in these students, especially in the lower limbs, one of the main regions affected by military injuries, will allow the development and implementation of prevention and training programs for this group. Thus, the purpose of this study was to evaluate the association between the occurrence of any musculoskeletal pain or discomfort and possible risk factors in military high school students.

Methods

The legal guardians received written information about the study. Subsequently, they were asked to provide written informed consent and the students were asked to provide their assent. This study was approved by the Research Ethics Committee of the Hospital Naval Marcílio Dias (CAAE: 50405615.4.0000.5256).

Study design

This was a prospective study. The students were evaluated at the beginning of the course to detect potential risk factors for musculoskeletal symptoms over a period of 16 months (follow-up period). Participants were evaluated in two consecutive days: Day 1: anamnesis and physical tests; Day 2: Cooper 12-min run test. Then, the participants were followed for 16 months, allowing the registration of musculoskeletal symptoms.

Participants

We included in this study male participants, aged 15 to 18 years, who were in the first week of the first year of a Brazilian military High School. The students with an injury or surgery history that prevented them from participating in the tests were excluded from the study. After this initial week, students will complete the course for approximately three years.

Baseline evaluation

Anamnesis form

Initially, students completed an anamnesis form composed of the following personal data and information about their lifestyle prior to the course: age, location of residence (urban or rural), previous sports practice, strength training for lower limbs, parent occupation (physical or non-physical), practice of sports competitions, frequency of aerobic exercises ≥ 3 times a week. In addition, students completed the Nordic Musculoskeletal Questionnaire (NMQ)[20], in which they reported any musculoskeletal symptoms in the 12-month period preceding the Course. A musculoskeletal symptom was defined as any pain or discomfort in muscles, bones or joints. Only the symptoms that were related to the course activities (gait, drill exercises, military physical training etc.) with time loss with more than least 24 hours were considered[21]. The NMQ allows students to point out the body regions in which there were musculoskeletal symptoms, and has four additional information: any musculoskeletal symptoms in the body regions; whether the symptom prevented students from performing their activities before the course; if there was a need for health care because of the musculoskeletal symptom; and whether the symptom has occurred in the past seven days. In this case, the students also classified pain according to the visual analog scale (zero to 10 points).

Body composition

The next step was to assess the percentage of body fat, BMI, and waist circumference. The evaluations were made during the morning by the same evaluator, with experience in anthropometric evaluation. Students did not perform physical activities on the day of the test, and they were submitted to the same feeding routine. Body fat percentage was estimated by the equations of Jackson and Pollock[22] (skin folds of chest, abdomen and thigh) and Slaughter[23] (skin folds of triceps and calf) in students older than or under 18 years of age, respectively using the Scientific Premier adipometer, Cescorf, Brazil. BMI was calculated by the following equation: weight (kg)/height^2 (m)[24], using the digital scale with stadiometer (Prix, Brazil). The Waist circumference was measured with the subject standing, at an intermediate distance between the last rib and the superior iliac crest, using a metallic anthropometric tape measure with 0.1 cm resolution.

Fitness tests

The students performed on the first visit (Day 1) the following physical tests to assess muscle strength, and flexibility: a) **Sit-up test** performed in the supine position with the knees flexed at 45° and with hands behind the neck. The student performed maximum repetitions in one minute, raising the upper body until his elbows touches the knees and then returns to the starting position where both scapulas touches the floor; b) **Pull-ups** suspended with arms outstretched on a fixed bar and supine grip with your hands on distance from the shoulders, performing a flexion raising the body until the chin touched or exceeded the bar and then go back to the starting position computing the maximum repetitions; c) **Push-ups:** the student started the test from the lowest face-down position and hands are kept at the shoulder-wide level. During the push-up, the student was required to fully extend his arms while keeping the body straight with tensed trunk muscles. Then, the body was lowered to the down position with an elbow angle of 90° with the support of both hands and both feet, body in extension and elbows extended, the evaluated performed an elbow flexion until they were at the shoulder level, returning to the starting position performing the elbow extension computing maximum repetitions in one minute; d) **Back extensions** maximum number of trunk extensions in the prone position on the floor with hands behind the neck in the starting position. During the movement, the upper body is lifted until the scapulas are approximately 30 cm higher than in the starting point. Thereafter, the upper body is lowered down back to the starting position, performing the elbow extension computing maximum repetitions in one minute; e) **Standing long-jump test** started with legs close to each other and bilateral takeoff is assisted by swinging of the upper body and arms. The landing is bilateral and shortest distance expressed in meters from the landing to the starting point was measured. jumping and landing as far as possible with both feet simultaneously. Three repetitions were performed; f) **Unilateral standing long-jump** started with legs close to each other and bilateral takeoff is assisted by swinging of the upper body and arms. The jump is initiated unilaterally, but landing occurs with bilateral support. The landing is unilateral and shortest distance expressed in meters from the landing to the starting point was measured. Three repetitions were performed on each side; and g) **Sit and reach test** with a sit and reach box (Cardiomed, Brazil). The student was sitting on the floor with legs stretched out straight ahead. The soles of the feet are placed flat against the box. Both knees should be locked and pressed flat to the floor. The, with the palms facing downwards, and the hands on the top of each other or side by side, the subject reaches forward along the measuring line as far as possible achieved with the fingertips. Three repetitions were performed, and the best was considered.

On the second visit (Day 2), cardiorespiratory fitness was evaluated with the Cooper 12-min run test[25,26]. In this test, students had to run as far as possible in 12 min. The test was carried out on an athletic track.

Musculoskeletal symptoms

After 16-month, the students' reported musculoskeletal symptoms with the NMQ[20]. The number of students who reported musculoskeletal symptoms in the following regions: neck, shoulder, back (upper region), elbow, wrist, back (lower region), hip (or thigh), knee and/or ankle was also described. Health professionals responsible for collecting information on complaints, pain or musculoskeletal discomfort were unaware of baseline test results.

Statistical analysis

For statistical analysis, IBM SPSS Statistics version 24.0 was used. Descriptive data are presented as number of students with musculoskeletal symptoms by anatomical region and their frequency. Results of the baseline evaluation (age, body composition and physical fitness) were presented as mean and standard deviation (SD).

A 2x2 table was developed with the socio-demographic, lifestyle and previous symptoms variables at the baseline evaluation. For the prediction analysis, we considered as reference patterns: physical parent's occupation; postgraduate (parent's educational level); rural residence; previous sports practice; previous strength training in lower limbs; previous sports competitions participation; aerobic training ≥3x/week and absence of previous musculoskeletal symptom.

To evaluate if there was a significant difference between the number of musculoskeletal complaints among regions of trunk, lower limbs and upper limbs, a Proportion Comparison Test was performed.

The best result of the three attempts of the standing landing jump test was normalized by height (% SLJT). For unilateral standing long-jumps, the best result of three attempts on each side was considered for the analysis. Subsequently, the percentage delta between the right and left sides was calculated (USLJT).

To assess the association between musculoskeletal symptoms after a follow-up of 16 months and independent variables, a univariate analysis was initially performed. The independent variables investigated were previous symptoms, age, BMI, fat percentage, % SLJT, USLJT, pull-ups, sit-ups, push-ups, back extensions, Cooper's Test, previous sports practice, previous strength training practice for lower limbs, waist circumference, sit and reach test, parents 'occupation, parents' educational level, residence, practice of previous sports competitions, frequency of aerobic training equal to or greater than 3x/week. Regarding the dependent variable, three distinct analyses were performed considering types of dependent variables: 1) *Any symptom*: the occurrence of musculoskeletal symptoms in any body region (AI); 2) *Any symptom with time-loss*: musculoskeletal symptoms with time-loss; 3) *Lower limbs symptoms*: musculoskeletal symptoms in the lower limbs. In this study, we considered "time-loss symptoms" those that promoted withdrawal or some adaptation of functions due to pain. If $p \leq 0.10$, the variable was be inserted in a bivariate logistic regression analysis. An "forced entry" analysis was performed, whose independent variables were be inserted into the model, one at a time, starting with the one with the highest magnitude of association in the Chi-square test. After the final equation obtained, variables whose OR values were different from 1 were considered significant, that is, whose confidence interval was 95% (95% CI), that is, with $P \leq 0.05$.

The sample power was calculated in the G-power 3.1.9.4 Software using the following parameters: two-tailed analysis, result of the Odds Ratios obtained in logistic regression, proportion between students with and without musculoskeletal symptoms at the end of the follow-up period and an α error of 0.05.

Results

The flow diagram of the included participants (n = 86) is presented in the Figure 1. Students included in the study were 16.0 ± 1.0 years; 172.8 ± 5.2 cm; 67.58 ± 3.2 kg, 22.4 ± 3.2 BMI and had 15.7 ± 6.6% of body fat. The results of the test carried out at the baseline evaluation are in Table 1 and the anatomical distribution of musculoskeletal symptoms reported during the 16-month follow-up is in the Table 2 and. Some students reported symptoms in more than one anatomical region.

Proportion Comparison Test showed no difference between knee and shoulders, hip or thigh and neck (P = 0.21; P = 0.10; and P = 0.10, respectively). However, the proportion of students with complaints in the knee was greater than the lower back (P = 0.04).

The results of the baseline evaluation with the 2x2 table for categorical variables (sociodemographic, lifestyle and previous symptoms) are presented in Table 3 and the results of univariate analysis are in Table 4. For Any symptom, only the variables % SLJT, age and parent's occupation presented $P < 0.10$, making possible the inclusion in the model. For time-loss symptom, the variables with $P < 0.10$ were previous sports practice and previous sports competitions. For lower limb symptom, parent's occupation and previous sports competitions presented $P < 0.10$. Thus, the regression logistic analysis detailed in the Table 5.

Bivariate logistic regression analysis showed association among the age and parent's occupation and any musculoskeletal symptom in any body region (OR = 0.50, 95% CI = 0.26-0.92; OR = 4.68, 95%CI = 1.70-12.82, respectively). For time-loss symptoms, no association between independent variables and risk of symptoms. Considering only complaints in lower limbs, the only variable that showed association with the symptoms of

Table 1 - Results of the baseline evaluation (age, body composition and physical fitness).

Variables		**Mean**	**SD**
Age	-	16.10	0.82
Body composition	BMI	22.40	3.20
	Body fat percentage	15.87	6.40
	Waist circumference	77.66	7.13
Physical fitness	Sit and reach	24.15	7.70
	% SLJT	109.0	14.4
	% USLJT	5.20	4.30
	Pull-ups (repetitions)	5.00	4.30
	Back extension (repetitions)	46.00	16.7
	Sit-ups (repetitions)	35.00	7.50
	Push-ups (repetitions)	27.00	9.10
	Cooper Test (m)	2251.00	338.20

BMI = body mass index; % SLJT = standing long-jump test normalized by height; % USLJT = unilateral standing long-jump test normalized by height; SD = Standard Deviation.

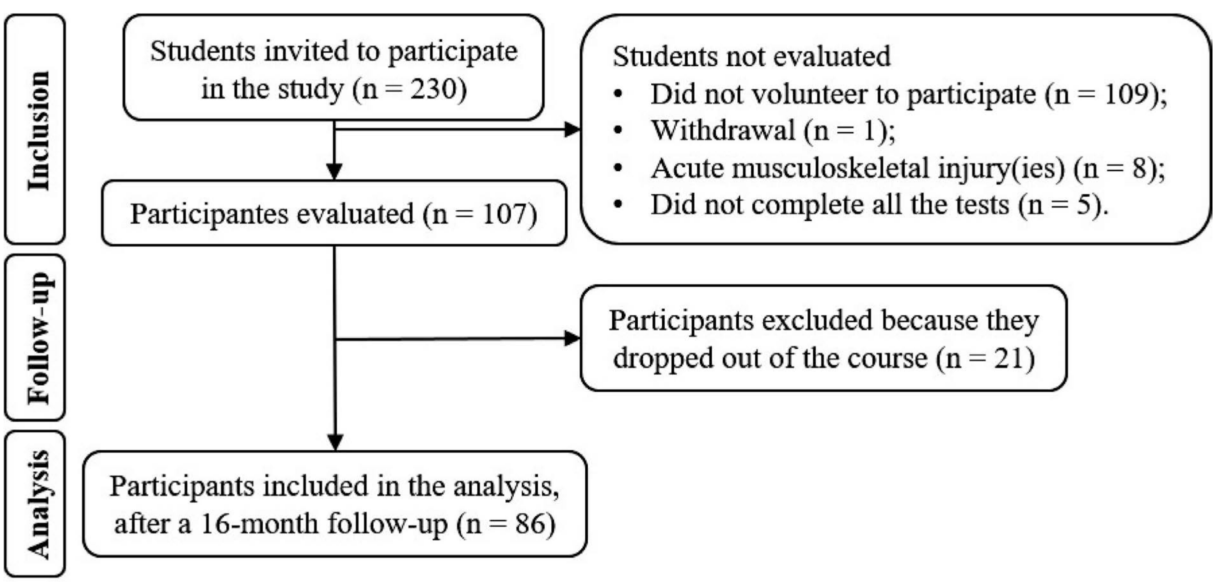

Figure 1 - Flow diagram of the included students.

pain or discomfort was the parent's occupation non-physical (OR = 3.1, 95% CI = 1.28-7.63).

Considering the lowest significant odds ratio value found, which was related to the variable "age", the sample power calculated was 0.80.

Table 2 - Musculoskeletal pain or discomfort by body region after 16 months follow up.

Body region	Students with pain or discomfort	Percentage of students
Neck	15[#]	17.4%
Shoulders	17[#]	19.7%
Upper back	10*	11.6%
Elbows	3*	3.0%
Hands	7*	8.0%
Lower back	13*	15.1%
Hips or thighs	15[#]	17.4%
Knees	24[#]	27.9%

[#]There were no significant differences in the Proportion Comparison Test (P > 0.05)
[*]Significant difference in the Proportion Comparison Test in relation to the total number of students with knee symptoms (P > 0.05).

Table 3 - Results of the baseline evaluation (sociodemographic, lifestyle and previous symptoms).

Type	Variables	Categories	Total
Sociodemographic	Parents occupation	Physical	38
		Not physical	48
	Parents' educational level	Postgraduate	20
		University	26
		High school	33
		Fundamental	4
	Residence	Urban	84
		Rural	2
Lifestyle	Previous sports practice	Yes	27
		No	59
	Previous strength training in lower limbs	Yes	24
		No	62
	Previous sports competitions	Yes	25
		No	61
	Aerobic training ≥ 3x/week	Yes	30
		No	55
History of injury	Previous musculoskeletal symptom	Yes	52
		No	34

Table 4 - Results of univariate analysis.

		Any symptom			Time-loss symptom			Lower limb symptom		
Variable	Reference	OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
BMI	Normal/underweight	1.01	0.98-1.15	0.84	1.03	0.87-1.23	0.67	0.97	0.85-1.12	0.73
Fat%	*	1.004	0.94-1.07	0.81	0.98	0.89-1.06	0.62	0.97	0.91-1.05	0.51
% SLJT	*	0.97	0.94-1.00	0.07	1.008	0.97-1.05	0.69	0.98	0.95-1.01	0.31
USLJT	*	1.86	0.16-21.31	0.60	0.000	000-	0.99	3.18	0.28-36	0.35
Pull-ups	*	0.93	0.83-1.03	0.15	1.006	0.88-1.14	0.93	0.98	0.88-1.09	0.70
Sit-ups	*	0.95	0.90-1.01	0.10	0.98	0.91-1.05	0.61	0.95	0.87-1.01	0.12
Push-ups	*	0.98	0.93-1.03	0.45	1.007	0.95-1.06	0.83	0.97	0.92-1.02	0.25
Back extension	*	0.997	0.97-1.02	0.81	1.026	0.99-1.06	0.14	0.99	0.97-1.02	0.66
Cooper Test	*	0.99	0.99-1.00	0.41	1.00	0.99-1.00	0.58	1.00	0.99-1,00	0.65
Previous injury	No	1.04	0.43-2.47	0.92	2.25	0.66-7.67	0.19	1.658	0.67-4.09	0.27
Previous sports practice	Yes	1.50	0.60-3.78	0.38	2.26	0.88-8.16	0.08	2.10	0.83-5.31	0.11
Strength training (lower limbs)	Yes	0.71	0.29-1.85	0.48	2.42	0.78-7.49	0.12	0.69	0.26-1.85	0.46
Age	*	0.62	0.36-1.06	0.08	1.008	0.52-1.97	0.98	0.80	0.47-1.37	0.11
Waist circumference	*	1.13	0.75-1.70	0.56	1.26	0.79-2.02	0.33	1.54	0.45-5.34	0.69
Sit and reach	*	0.97	0.92-1.03	0.34	0.98	0.91-1.05	0.48	1.01	0.96-1.07	0.68
Parent's occupation	Physical	3.30	1.35-8.10	0.009	1.81	0.60-5.44	0.28	6.51	2.49-16.19	0.00
Parent's educational level	Postgraduate	0.72	0.44-1.19	0.20	0.66	0.35-1.25	0.20	0.50	0.04-5.70	0.92
Residence	Rural	1.10	0.07-18.17	0.94	$38x10^{7}$	000-?	0.99	1.55	0.93-25.57	0.76
Previous sports competitions	Yes	0.51	0.20-1.33	0.16	0.32	0.10-0.99	0.047	0.38	0.15-0.99	0.045
Aerobic training		0.60	0.24-1.47	0.26	0.64	0.21-1.95	0.43	0.75	0.30-1.85	0.52

BMI = body mass index; OR = odds ratios; Fat% = body fat percentage; % SLJT = standing long-jump test normalized by height; % USLJT = unilateral standing long-jump test normalized by height.

Table 5 - Associations between variables and any musculoskeletal symptoms among military high school students.

Dependent variable	Independent Variable	OR	P	95% CI		R2	
				Lower	Upper	Cox & Snell	Nagelkerke
Any musculoskeletal symptoms	Parent's occupation non-physical	4.68	0.003	1.708	12.823		
	% SLJT	0.97	0.076	0.937	1.003	0.17	0.23
	Age	0.50	0.027	0.266	0.921		
Time-loss musculoskeletal symptoms	Previous sports practice	$25x10^7$	0.99	0.000	.		
	Previous sports competitions	0.240	0.99	0.000	.	0.05	0.08
Lower limb musculoskeletal symptoms	Parent's occupation non-physical	3.072	0.016	1.237	7.633		
	Previous sports competitions	0.240	0.36	0.581	4.339	0.09	0.12

OR = Odds ratios; % SLJT = standing long-jump test normalized by height.

Discussion

The results of the present study indicate that age is a protective factor for musculoskeletal symptoms in any region of the body in military students during the military high school course (OR = 0.50; 95% CI = 0.26-0.92), with a 50% lower probability of developing any symptom during the course among the oldest students. A non-physical parent's occupation showed an odds ratio of 4.68 (95% CI = 1.70-12.82), with 4.68 times more chance of developing musculoskeletal symptoms in any body region during the course. Considering only lower limbs symptoms, non-physical parent's occupations increase more than three times the chance of musculoskeletal symptoms (OR = 3.1; 95% CI = 1.28-7.63).

The most affected region is the lower limbs, followed by the trunk region, and the upper limbs region. It is also possible to conclude from the Proportions Comparison Test that there is a significant difference (P > 0.05) between the number of students reporting musculoskeletal injury symptoms in knees compared to the number of students reporting symptoms in trunk (upper and lower back), elbows, or hands. A total of 45.35% of the students reported musculoskeletal symptoms in the lower limbs (hip, thigh, or knee). Similar results were found in previous studies regarding musculoskeletal injuries and activities inherent to military training, such as walking exercises and drills. Some authors suggest that the high incidence of musculoskeletal injuries in lower limbs is associated with biomechanical overload. While performing exercises in military training courses, the lower limbs are subjected to an overload equal or greater than the overload performed during running, which is considered a high-impact activity, and may contribute to the high incidence of musculoskeletal overuse injuries[27].

A previous systematic review showed that the oldest militaries had a 22% higher risk of injury than young people[28]. Although the outcome was injury, and not just symptoms of pain and discomfort, they also showed that the risk was more significant in follow-up periods of less than 12 months (RR = 1.35; P = 0.0006), different to the present study. Whose results became significant after the first year. Although previous studies have shown that previous injuries increase the risk of a new injury, in the present study, there was no such association between previous musculoskeletal pain and the symptom at the 16-month follow-up.

Contrary to the present study, not physical parent's occupational status was not associated with an increased risk of musculoskeletal injuries (6). Despite the potential stimulus to the practice of physical activities by family members with more active occupations, a possible cause for the difference in results with the present study may have been the age group of the participants.

Despite the different age groups between our study (16.0 ± 1.0 years) and other studies (23.3 ± 3.7 or 19 years)[6,28], in all cases the students performed various types of similar physical activities (walking, running, training exercises, among others). Although there is an increase in physical conditioning and lean body mass as a result of military training[8], in the present study, low levels of aerobic conditioning, poor performance on muscular endurance tests, and high BMI were not associated with an increased risk of injury, contrary to previous studies with military adults[6]. There was an absence of association between the Cooper Test, previous sport experience and the muscular endurance tests with musculoskeletal symptoms.

Possibly, these differences may have elapsed from age group of the participants. In the present study, maturation plays an important role. Height, total body mass, BMI, bone age, bone diameters, muscle circumferences and other basic physical qualities change with the onset of puberty[29]. The poor performance in some tests may have been due to the maturational stage of some students who have not yet reached the mature musculoskeletal system. Another possible explanation for the lack of association may have been the analysis of complaints of pain or musculoskeletal symptoms. However, we also analyzed the musculoskeletal symptoms that promoted withdrawal from the students' functions.

This study has some limitations. First, it was not possible to carry out the evaluation in all students, since only 109 students (47,39%) were not authorized by their legal guardians to participate. A total of 35 students were excluded due to acute injury at the time of evaluation or dropping out of the course. Second, no flexibility tests or functional tests were conducted that could address potential movement patterns associated with increased risk of injury. Third, the evaluation of student maturation was not performed. The low maturation level of high school athletes is considered a predictive factor for musculoskeletal symptoms, although with a limited level of evidence[30].

However, this study has strengths, such as to prospectively evaluate potential risk factors for musculoskeletal complaints and their distribution in military high school students. Second, health professionals responsible for collecting information on complaints, pain or musculoskeletal discomfort were unaware of baseline test results, minimizing the observation bias. Finally, to minimize potential confounding factors, the influence of covariables was analyzed by logistic regression analysis.

Conclusion

We concluded that age is a protective factor for musculoskeletal symptoms in any region of the body in high school military students. On the other hand, non-physical parent's occupation increased the chance of musculoskeletal symptoms from 3.1 to 4.68 times in lower limbs and in any body region during the course, respectively. It is suggested the application of an anamnesis form at the beginning of the courses in order to map the socioeconomic profile of the students, as well as the realization of physical exercise programs for the younger students. Future studies should follow the sample in terms of the components of physical conditioning and maturational status and evaluate their associations with the risk of injuries or musculoskeletal symptoms.

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