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Injury acknowledgement by reduction of sports load in world-leading athletics (track and field) athletes varies with their musculoskeletal health literacy and the socioeconomic environment

Toomas Timpka ^{1,2}, Kristina Fagher ^{1,3}, Victor Bargoria,¹ Christer Andersson,^{1,2} Jenny Jacobsson ^{1,2}, Håkan Gauffin ^{1,4}, Per-Olof Hansson,^{1,5} Paolo Emilio Adami ⁶, Stéphane Bermon ^{6,7}, Örjan Dahlström ^{1,8}

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¹Athletics Research Center, Linköping University, Linköping, Sweden

²Department of Health, Medicine and Caring Sciences, Linköping University, Linköping, Sweden

³Department of Health Sciences, Lund University, Lund, Sweden

⁴Department of Orthopedics, Linköping University, Linköping, Sweden

⁵Department of Management and Engineering (IEI), Linköping University, Linköping, Sweden

⁶Health and Science Department, World Athletics, Monte Carlo, Monaco

⁷LAMHES, Université Côte d'Azur, Nice, France

⁸Department of Behavioural Sciences and Learning, Linköping University, Linköping, Sweden

Correspondence to

Professor Toomas Timpka, Athletics Research Center, Linköping University, Linköping 581 83, Sweden; toomas.timpka@liu.se

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ABSTRACT

Objective Although injury burden prompts elite athletics (track and field) athletes to engage in injury management, little is known about their health literacy. We investigated musculoskeletal (MS) health literacy in world-leading athletics athletes and associations with prechampionship injury acknowledgement by reduction of training load in different socioeconomic environments.

Methods Adult and youth athletics athletes (n=1785) preparing for World Championships were invited to complete the Literacy in Musculoskeletal Problems instrument and report acknowledgement of injury by reduction in training load during prechampionship tapering. Their socioeconomic standing was estimated through the Human Development Index of their home country. Demographic differences were examined using χ^2 tests and determinants of injury acknowledgement assessed using logistic regression.

Results Complete data were obtained from 780 athletes (43.7%) with 26% demonstrating sufficient MS health literacy, higher in adult (41%) than youth (13%) athletes ($p<0.001$). Adult athletes at the uppermost socioeconomic level showed higher MS health literacy than athletes at lower socioeconomic levels ($p<0.001$). At the uppermost socioeconomic level, adult athletes with sufficient MS health literacy had increased likelihood of acknowledging an injury by reduction in training load compared with peers demonstrating insufficient MS health literacy (OR=2.45; 95% CI 1.33–4.53). Athletes at middle socioeconomic levels with sufficient MS health literacy had decreased likelihood for acknowledging an injury during tapering (OR=0.29; 95% CI 0.11–0.78).

Conclusions The prevalence of sufficient MS health literacy in world-leading athletics athletes is low. Associations between MS health literacy and injury acknowledgement in these athletes vary with the resourcefulness of the socioeconomic environment, implying that health literacy and resources for medical and performance support should be ascertained concurrently.

INTRODUCTION

The heavy burden of musculoskeletal injury in elite athletics (track and field)^{1–3} prompts athletes to engage in performance health management.⁴ For athletics athletes competing at the highest level, the ultimate goal is to achieve the best possible

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The heavy burden of musculoskeletal injury in elite athletics (track and field) prompts athletes to engage in performance health management.

WHAT THIS STUDY ADDS

- ⇒ Musculoskeletal health literacy is low in world-leading athletics athletes.
- ⇒ Sufficient musculoskeletal health literacy is positively associated with higher socioeconomic status in adult elite athletics athletes.
- ⇒ In socioeconomically resourceful environments where sports and exercise medicine support is typically easily available, adult athletics athletes with sufficient musculoskeletal health literacy are more likely to reduce training load in response to an injury than their peers with insufficient literacy.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Adequate health literacy and ample support resources should be established for leading athletics athletes together to guide appropriate load adjustments in association with injury symptoms.

performance at major international championships. Maintaining health during the prechampionship (tapering) period is essential but can be challenging for these athletes, with approximately one in three athletes arriving at major championships having sustained an injury in the previous month.^{5–7}

Health literacy is the degree to which individuals can obtain, process and understand the basic health information and services they need to make appropriate health decisions.^{8,9} Qualitative research has indicated that elite athletes prioritise performance enhancement rather than injury management¹⁰ and are at risk for ‘explaining away’ symptoms which gradually develop immediately prior to important competitions.¹¹ These observations highlight the need for adequate health literacy among elite athletes in their decision-making before major championships. The Literacy in Musculoskeletal Problems (LiMP) instrument was developed specifically to identify individuals at risk for receiving

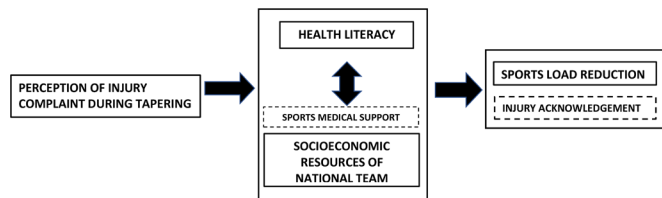


Figure 1 Theoretical model of elite athletics athletes' perception of an injury complaint during prechampionship tapering, health literacy and socioeconomic resources of the national team (sports medical support) and sports load adjustment (acknowledgement of injury).

suboptimal medical support for musculoskeletal complaints due to low health literacy.¹² The instrument has been reported to have satisfactory reliability and a moderate positive correlation with general health literacy.¹³

Knowledge about the distribution of musculoskeletal health literacy (MS health literacy) among athletes in high-performance sports contexts is largely lacking. We aimed to investigate the MS health literacy in world-leading youth and adult athletics athletes and study the associations between MS health literacy, socioeconomic resourcefulness and injury acknowledgement by reduction of sports load during prechampionship tapering. Because health service availability influences the possibility to consult clinical professionals,^{14 15} associations between MS health literacy and reduction of sports load were assumed to vary with the socioeconomic resourcefulness of the athlete's national team (figure 1).

METHODS

Study design

A retrospective cohort design was used for the study. The primary outcome measure was injury acknowledgement during prechampionship tapering (delineated as the 4-week preparation period before championships). Injury acknowledgement was defined as reduction of scheduled sports load in response to an injury complaint. The gradual onset of the typical overuse injuries in athletics predisposes for 'explaining away' injury symptoms.¹¹ The national teams registered for the World Athletics Championships and the World Athletics Under 18 Championships in 2017 were considered for participation. From this population were excluded teams that: (a) were unfamiliar with any of the nine study languages (English, Spanish, Arabic, French, Portuguese, Chinese, Amharic, Russian and Japanese); (b) had to comply with a restricted team communication policy during championships; and/or (c) were quarantined at their hotel (during the World Championships due to a norovirus outbreak).

Ethical considerations

Participation was voluntary and all participants provided informed consent. Data were treated confidentially and presented in aggregated form. The study follows the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.

Patient and public involvement

The research questions analysed in this study were developed in consultation with a reference group of 16 youth and adult (females and males) elite athletics athletes representing one European and one African country. The reference group also provided feedback on drafts of the survey used for data collection. The athletes were not involved in the choice of the outcome measures, recruitment of participants or conduct of the study.

The dissemination of the study results will be based on recommendations from the reference group.

Equity, diversity and inclusion statement

Our study included measurements of MS health literacy and acknowledged tapering injuries in world-leading athletics athletes inclusive of all genders, countries of origin and socioeconomic levels. Our author team consisted of two women and eight men from different disciplines (medicine, behavioural and learning sciences, epidemiology), including one author considered a junior scholar. Although we were researching socioeconomic factors, data collection was similar in all cases and we did not alter the methods based on educational, language or socioeconomic differences in the study population. Our study used the Human Development Index (HDI) to measure socioeconomic disadvantage. The potential influence of socioeconomic inequities on MS health literacy and injury outcomes is presented in the Discussion section.

Instruments

MS health literacy was investigated using the LiMP instrument,^{12 13} modified for the athletics context. This instrument includes nine multiple-choice questions that assess MS health literacy by evaluating the abilities needed to make informed decisions regarding musculoskeletal health. Each survey item is correspondingly associated with one of three themes: anatomy and terminology, musculoskeletal conditions and diagnosis and treatment. The themes address the ability to read, calculate and act on oral and written information in healthcare settings (functional MS health literacy) and analysing and evaluating the information (critical MS health literacy).^{9 16} The survey is intended to be simple and easy to read, and still provide objective insight into the respondent's abilities.

The original LiMP instrument was slightly modified to suit the athletics context (online supplemental figure 1). Two of the items covering diagnosis and treatment (item 2, medical imaging; item 8, pain causes and management) were modified to better suit the management of sports injuries.

Data collection

Athletes were invited to complete a preparticipation health questionnaire (PHQ) including questions on demographic data, such as sex, age and country. The PHQ was translated from English into the eight other study languages. Thereafter, back translations into English were performed to verify the validity of the translations. Data on acknowledged tapering injuries were collected by asking whether an injury complaint had resulted in a decision to reduce training or competition load during the 4 weeks of tapering prior to the championships. Structured follow-up questions were asked about the cause and location of the injury complaint. Participants were also asked to complete the LiMP instrument. The questionnaires were available as a web survey and in paper format. An invitation pamphlet containing a link to the electronic survey (Easy Survey) was distributed to the athletes in association with the accreditation process. All national medical teams and local organising committee physicians were informed about the study 1 month before the championships by email and 2 days before the championships in association with medical and antidoping meetings.

Data analysis

Consistent with previous definitions and terminology, LiMP scores were dichotomised (sufficient vs insufficient) using a score

Table 1 Study participants displayed by age group, sex and socioeconomic standing (Human Development Index (HDI) category for their country of origin)

Socioeconomic standing (HDI)	Youth athletes, n (%)			Adult athletes, n (%)			All athletes, n (%)		
	Females	Males	Total	Females	Males	Total	Females	Males	Total
Low	20 (10)	26 (12)	46 (11)	10 (5)	19 (11)	29 (8)	30 (8)	45 (11)	75 (10)
Medium-high	109 (55)	118 (53)	227 (54)	54 (29)	55 (31)	109 (30)	163 (43)	173 (43)	336 (43)
Very high	47 (24)	44 (20)	91 (22)	113 (61)	95 (53)	208 (57)	160 (42)	139 (35)	299 (38)
Undefined	21 (11)	33 (15)	54 (13)	7 (4)	9 (5)	16 (4)	28 (7)	42 (11)	70 (9)
Total	197 (100)	221 (100)	418 (100)	184 (100)	178 (100)	362 (100)	381 (100)	399 (100)	780 (100)

HDI category: low, <0.55; medium-high, 0.55–0.79; very high, ≥0.80.

≥6 as cut-off.^{12,13} The athletes' MS health literacy was described by the mean (SD) LiMP scores and as the proportion of athletes with scores above the cut-off (LiMP score ≥6). We used analyses stratified by age and socioeconomic standing to examine differences regarding baseline demographic characteristics and MS health literacy status. The socioeconomic standing of the athlete, used as a proxy for the resourcefulness of their support team during tapering, was determined using the developmental level of their home country as defined by the United Nations (UN) HDI¹⁷; the HDI categories used were as follows: low, <0.55; medium-high, 0.55–0.79; very high, ≥0.80. Correlations between MS health literacy and socioeconomic standing were determined using Kendall's tau. Comparisons of MS health literacy scores between age groups and between men and women were made using Wilcoxon rank-sum tests with Holm's correction for multiple comparisons. Differences in proportions of athletes with sufficient MS health literacy (yes/no) between youth and adult athletes, athletes with sufficient MS health literacy (yes/no) and different levels of socioeconomic standing (HDI categories) and athletes reporting tapering injury (yes/no) and socioeconomic standing (HDI categories) were examined using χ^2 tests with ϕ as the effect size measure. Associations between tapering injury acknowledged (yes/no) and sufficient MS health literacy (yes/no) within different HDI categories were examined using simple logistic regression models with ORs as the effect size measure.

RESULTS

Of the 1785 athletes invited, 780 (43.7%) returned the PHQ data; 362 respondents were adult athletes (184 females and 178 males) and 418 were youth athletes (197 females and 221 males) (table 1).

LiMP score distribution

The mean total LiMP score for all participants was 4.01 (SD, 2.19); the mean score was higher ($p<0.001$) for adult athletes (mean, 4.93; SD, 2.12) than for youth athletes (mean, 3.21; SD, 1.91). A positive correlation was observed between the LiMP score and the athletes' socioeconomic standing (Kendall's $\tau=0.20$; $p<0.001$) (online supplemental figure 2). No significant difference in LiMP scores with regard to sex was observed among all athletes ($p=0.17$), youths ($p=0.92$) or adults ($p=0.12$).

MS health literacy by age group

Twenty-six per cent of the respondents displayed sufficient MS health literacy according to their LiMP score (table 2); more adult athletes (41%) than youth athletes (13%) attained this status ($p<0.001$; $\phi=0.31$). Regarding the LiMP subthemes, the highest proportion of athletes with sufficient MS health literacy was observed regarding anatomy terminology in both

age categories (youths, 54%; adults, 80%); the lowest proportion was observed regarding diagnosis and treatment (youths, 20%; adults, 40%). The proportion of individuals with sufficient MS health literacy was higher among the adult athletes than the youth athletes for all subthemes ($p<0.001$; $\phi=0.21$ – 0.27).

MS health literacy by socioeconomic environment

Adult athletes at the highest level of socioeconomic standing (very high HDI) displayed significantly higher MS health literacy with regard to the total LiMP score than athletes at the lower levels (medium-high or low HDI) (table 3). No statistically significant differences in LiMP score with regard to socioeconomic standing were observed in youth athletes.

Tapering injury acknowledgement by socioeconomic environment

About 32% of the athletes reported having reduced their sports load due to an injury during tapering (table 4). Twenty-nine per cent of the athletes reported having changed their schedule due to an overuse injury (30% of youth and 28% of adult athletes), and 3% of both youth and adult athletes had adjusted their schedule due to injuries experienced in traumatic events. There were no significant sex differences in the distribution of athletes acknowledging an injury among youth athletes ($\chi^2(df=1, N=397)=0.25, p=0.62$) or adult athletes ($\chi^2(df=1, N=363)=0.40, p=0.53$). The most common location for overuse injuries was the thigh (13%), followed by the lower leg (13%) and the knee (12%). The overall likelihood of acknowledging an injury by reducing sports load showed no significant association to the athlete's socioeconomic environment among youth athletes ($\chi^2(df=2, n=348)=2.93, p=0.23$) or adult athletes ($\chi^2(df=2, n=349)=0.87, p=0.65$).

MS health literacy and socioeconomic resources in injury acknowledgement

At the highest level of socioeconomic standing, there was an increased likelihood of reducing sports load having acknowledged the occurrence of an injury for adult athletes with sufficient MS health literacy compared with their peers with insufficient MS health literacy (OR=2.45; 95% CI 1.33–4.53); for adult athletes at the middle level of socioeconomic standing, the likelihood for changing schedule due to an injury was lower for athletes with sufficient MS health literacy (OR=0.29; 95% CI 0.11–0.78) (table 5). No associations between acknowledging a tapering injury and MS health literacy were observed among youth athletes or adult athletes at the lowest level of socioeconomic standing. Disregarding the athlete's socioeconomic environment, the odds for acknowledging an injury did not increase or decrease with sufficient MS health literacy.

Table 2 Number (per cent) of athletes with sufficient MS health literacy (LiMP score ≥ 6 ; total score and subtheme scores) displayed by age group and socioeconomic standing (Human Development Index (HDI) category) (n=780)

LiMP score according to socioeconomic standing (HDI)	Youth athletes, n (%)	Adult athletes, n (%)	All athletes, n (%)	P value	ϕ
Total score					
Low	2 (4)	3 (10)	5 (7)	0.369*	
Medium-high	33 (15)	33 (30)	66 (20)	0.001	0.18
Very high	17 (19)	105 (50)	122 (41)	<0.001	0.29
All categories	55 (13)	147 (41)	202 (26)	<0.001	0.31
Anatomy/terminology					
Low	25 (54)	17 (59)	42 (56)	0.901	
Medium-high	128 (56)	78 (72)	206 (61)	0.011	0.14
Very high	42 (46)	179 (86)	221 (74)	<0.001	0.41
All categories	226 (54)	288 (80)	514 (66)	<0.001	0.27
Musculoskeletal conditions					
Low	6 (13)	6 (21)	12 (16)	0.519*	
Medium-high	71 (31)	48 (44)	119 (35)	0.030	0.12
Very high	21 (23)	114 (55)	135 (45)	<0.001	0.29
All categories	106 (25)	178 (49)	284 (36)	<0.001	0.24
Diagnosis/treatment					
Low	6 (13)	6 (21)	12 (16)	0.519*	
Medium-high	45 (20)	33 (30)	78 (23)	0.047	0.11
Very high	28 (31)	99 (48)	127 (42)	0.010	0.15
All HDI categories	84 (20)	144 (40)	228 (29)	<0.001	0.21

Differences between youth and adult athletes are shown (p value for χ^2 test with ϕ as the effect size measure). HDI category: low, <0.55; medium-high, 0.55–0.79; very high, ≥ 0.80 .
*Fisher's exact test.
LiMP, Literacy in Musculoskeletal Problems; MS, musculoskeletal.

DISCUSSION

We aimed to investigate MS health literacy in world-leading athletics athletes and study associations between MS health literacy and injury acknowledgement by reduction of sports load during prechampionship tapering. A noteworthy 87% of the youth athletes displayed an insufficient MS health literacy compared with 59% of their adult peers. Among the adult athletes, the direction of the association between MS health literacy and reduction of sports load following acknowledgement of an injury varied with the athlete's socioeconomic environment. No association between MS health literacy and

injury acknowledgement was observed in the youth elite athletes, which could be explained by the overall low MS health literacy in this age group.

MS health literacy, support resources and injury acknowledgement

About half of the adult athletes showed sufficient MS health literacy, which is close to the average health literacy status reported from general adult populations.¹⁸ In comparison, only about 1 in 10

Table 3 LiMP total score (mean (SD)) for athletes in categories of socioeconomic standing defined by the Human Development Index (HDI) and differences in LiMP score (p values) between athletes in the different categories

Athlete age group	Socioeconomic standing (HDI)	Athletes responding to MS health literacy questions (n)	LiMP score, mean (SD)	Score differences (P value)	
				Low HDI	Medium-high HDI
Youth athletes	Low	46	2.80 (1.81)		
	Medium-high	227	3.41 (1.79)	0.125	
	Very high	91	3.23 (2.28)	0.600	0.600
	All	418			
Adult athletes	Low	29	3.52 (1.64)		
	Medium-high	109	4.40 (2.45)	0.042	
	Very high	208	5.38 (1.85)	<0.001	0.001
	All	362			
All athletes	Low	75	3.08 (1.77)		
	Medium-high	336	3.73 (2.08)	0.013	
	Very high	299	4.73 (2.22)	<0.001	<0.001
	All	780			

P values for Wilcoxon rank-sum test with Holm's correction for multiple comparisons are shown. HDI category: low, <0.55; medium-high, 0.55–0.79; very high, ≥ 0.80 . n=28 athletes (22 youths and 6 adults) did not respond to questions about injuries and are not included.
LiMP, Literacy in Musculoskeletal Problems; MS, musculoskeletal.

Table 4 Number (per cent) of athletes who had reduced their sports load having acknowledged the occurrence of an injury (overuse or traumatic) during the prechampionship tapering displayed by age group, injury type and socioeconomic standing (Human Development Index (HDI) category of their home nation)

Injury type	Socioeconomic standing (HDI)	Tapering injury acknowledged, n (%)		
		Youth athletes (n=396)	Adult athletes (n=356)	All athletes (n=752)
Overuse		118 (30)	101 (28)	219 (29)
	Low	16 (35)	7 (24)	23 (31)
	Medium-high	66 (31)	35 (33)	101 (32)
	Very high	21 (24)	57 (27)	78 (26)
	Undefined	15 (31)	2 (15)	17 (27)
Traumatic		13 (3)	11 (3)	24 (3)
	Low	2 (4)	0 (0)	2 (3)
	Medium-high	7 (3)	3 (3)	10 (3)
	Very high	3 (3)	7 (4)	10 (3)
	Undefined	1 (2)	1 (8)	2 (3)
Total		131 (33)	112 (31)	243 (32)

HDI category: low, <0.55; medium-high, 0.55–79; very high, ≥0.80.
n=28 athletes (22 youths and 6 adults) did not respond to questions about injuries and are not included.

youth athletes displayed sufficient MS health literacy. The difference can be explained by the facts that the adult athletes had been exposed to more formal education and that they had needed to manage injury challenges during a longer career, requiring them to acquire basic knowledge of medical terminology and fundamental competence regarding health service access. Nonetheless, insufficient MS health literacy early in the career reduces a young athlete's capacity to manage injury problems and decreases the possibilities of reaching the highest level of competition.¹⁹ The low prevalence of youth athletes with sufficient MS health literacy in this study can be compared with a recent study that reported an almost three times higher prevalence in athletics athletes aged 12–15 years.²⁰ However, that study was performed in a sports community at a high socioeconomic level. The low prevalence of young elite athletes with sufficient MS health literacy observed in this study may therefore be explained by the large proportion of participants originating from environments where access to qualified health services was limited. The lack of experience using health services is likely to have limited the athletes' knowledge of adequate medical support utilisation for musculoskeletal complaints.^{12 21} This interpretation is supported by the association between MS health literacy and socioeconomic standing observed in our data.

In adult athletes at the highest socioeconomic level, sufficient MS health literacy was associated with an increased likelihood of reducing

sports load following injury acknowledgement during tapering, while in athletes at the middle socioeconomic levels sufficient MS health literacy was associated with a decreased likelihood for reduction of sports load. No association between MS health literacy and injury acknowledgement was observed in adult athletes at the lowest level of socioeconomic standing, which may be explained by the overall low prevalence of sufficient MS health literacy (10%) in this athlete category. A time-loss injury definition was used in this study, that is, tapering injury acknowledgement was defined by the athlete's factual decision to adjust their prechampionship schedule. At the highest socioeconomic level, athletes typically have regular access to a support team and medical consultancy during the prechampionship tapering.^{4 22} Consequently, the possibility to discuss even minor health issues with clinicians may have predisposed the athletes with sufficient MS health literacy to better understand whether a particular health issue could compromise championship performance compared with their peers with insufficient MS health literacy. In comparison, the lower likelihood for reducing sports load among athletes with sufficient MS health literacy at the middle socioeconomic levels may be related to lower availability of support resources in the national teams and that deliberations about injury complaints mainly were performed between athletes and their coaches.

Implications of study findings

The instrument used in this study to measure MS health literacy was developed to identify individuals at risk of receiving suboptimal medical support for musculoskeletal complaints.¹² The results show that MS health literacy promotion is needed in elite athletics athletes, particularly among athletes in the youth category. Barriers to formal education among socioeconomically disadvantaged youths are a worldwide problem that has been even more pronounced during the COVID-19 pandemic with school closures leaving many young people without formal education for 1 year.²³ Therefore, it is essential that national and international sports federations contribute to the UN sustainability programme²⁴ by supporting quality education among all young people throughout the world. Although it has been acknowledged that there are specific health literacy needs in young competitive athletes, for instance, regarding doping issues,²⁵ knowledge about effective interventions in this group is limited. A recent intervention study in youth athletics based on a digital platform involving athlete-coach-parent triads has reported promising results.²⁶ However, for the further development of such interventions, the authors also conclude that better understanding of the unique environment for learning in youth sports is needed.

Regarding adult elite athletes, our findings imply that the association between MS health literacy and maintenance of performance health involves more determinants than the athlete's personal competencies and abilities.²¹ Contemporary preference-based medicine²⁷ requires the clinicians supporting an elite athletics

Table 5 ORs (95% CIs) for reduction of sports load having acknowledged the occurrence of a tapering injury among athletes with sufficient MS health literacy (LiMP score ≥6) compared with athletes with insufficient MS health literacy displayed by socioeconomic standing and age group

Socioeconomic standing (HDI)	Youth athletes OR (95% CI)	Adult athletes OR (95% CI)	All athletes OR (95% CI)
Low	1.32 (0.08–22.41)	1.12 (0.09–14.28)	1.06 (0.17–6.77)
Medium-high	0.93 (0.42–2.04)	0.29 (0.11–0.78)	0.58 (0.31–1.06)
Very high	0.52 (0.14–2.00)	2.45 (1.33–4.53)	1.79 (1.08–2.97)
All	0.72 (0.38–1.37)	1.22 (0.78–1.92)	0.99 (0.70–1.39)

Socioeconomic standing was estimated by the Human Development Index (HDI) category of the home country. HDI category: low, <0.55; medium-high, 0.55–0.79; very high, ≥0.80.
n=28 athletes (22 youths and 6 adults) did not respond to questions about injuries and are not included.
LiMP, Literacy in Musculoskeletal Problems; MS, musculoskeletal.

athlete before a championship to identify discrepancies between the athlete's actual performance health and championship planning, and communicate concerns with the athlete and coaches. For instance, a three-colour traffic light system has been developed to assist shared decision-making between sports medical practitioners, elite athletes and coaches about risk taking before major competitions.⁴ If signs of injury are detected, the clinicians support the athlete and coaches to determine a risk tolerance level.²⁸ Following such deliberations, a decision to not decrease sports load despite a verified injury complaint may be made considering intrinsic (eg, type of injury complaint) and extrinsic (eg, importance of competition) factors.²⁹ Nonetheless, performance health management before championships among athletes at the lower socioeconomic levels is presently less likely to involve shared decision-making with clinicians about medical risks.²² Although we did not collect detailed data on medical support, our findings are suggestive of that health literacy promotion and preference-based sports medical support should be introduced side by side in elite athletics environments.

Study strengths and limitations

A strength of this study is the large sample, representative of the international population of elite athletics athletes. The PHQ was back translated into eight languages by linguistics and athletics experts and 780 (43.7%) of the invited 1785 athletes participated and responded to MS health literacy questions. To the authors' knowledge, there are no earlier studies of MS health literacy in international populations of world-leading athletes. Moreover, in addition to the implications for health service planning in high-performance sports settings, the observation that the association between MS health literacy and injury acknowledgement varies with the athlete's socioeconomic environment highlights that the athlete's support resources should be considered when time-loss definitions are used for recording injuries.³⁰ However, there also are important limitations to consider. Athlete-level data were not collected on the specific performance health support received during tapering. Because the athlete's detailed knowledge of the performance health management organisation was assumed to be limited, the support level during the tapering was approximated using HDI data.³¹ Of note, elite athletics athletes from countries at the lower HDI levels often participate in international training groups in very high HDI countries. Many elite athletes therefore train in a socioeconomic environment that is different from the HDI level of their country of representation. Nonetheless, most athletes are during the prechampionship tapering period with their national team, and the medical support resourcefulness of these teams is normally proportional to the HDI of the country they represent.²² Also, the study was based on a retrospective design, which introduces a risk for memory recall errors in the reporting of injury events. However, the retrospective data only covered a 4-week tapering period, which suggests that the risk of bias should be relatively low.³² Additionally, our analysis did not involve the athletes' performances at the championships per se. Therefore, it is not known whether the athletes' decisions regarding reduction of sports load during the tapering influenced their performance at the World Championships. Regarding measurement of MS health literacy, the LiMP instrument has been validated for populations at risk for chronic musculoskeletal conditions, which also applies to elite athletics athletes. The low level of MS health literacy observed in elite youth athletes implies that further research focusing on this age group is warranted. Moreover, in performance health management among elite athletes, other and more specific cognitive and health resources may be needed for

prevention and self-management of health hazards.^{4 29 33 34} For instance, endurance athletes need health numeracy skills^{35 36} to assess the numbers for self-management of training load and nutrient intake. Therefore, a complete measurement of health literacy in elite athletes needs to cover more aspects than the management of musculoskeletal problems included in the basic LiMP instrument to cover all relevant aspects of performance health.

CONCLUSION

This study showed low levels of MS health literacy in world-leading athletics athletes, particularly in the youth category. National and international athletics federations should encourage talented young athletics athletes to continue their formal education in parallel with their sports participation and promote MS health literacy in elite athletes. The observation that associations between MS health literacy and injury acknowledgement through reduction of sports load vary with the athlete's socioeconomic environment implies that sufficient health literacy and resources for medical and performance support need to be established together to guide appropriate load adjustments when injury symptoms are recognised.

Twitter Kristina Fagher @KristinaFagher, Jenny Jacobsson @Jenny_Jacobsson and Paolo Emilio Adami @paolo_emilio

Contributors TT, SB, OD, KF, VB, CA, JJ, HG, P-OH and PEA contributed to the conception or design of the work. OD, KF, JJ, VB, HG, P-OH, CA, PEA, SB and TT contributed to the acquisition, analysis or interpretation of data for the work. TT, KF and OD drafted the manuscript. VB, HG, P-OH, JJ, CA, PEA and SB critically revised the manuscript. All authors gave final approval and agreed to be accountable for all aspects of the work ensuring integrity and accuracy. TT is the guarantor and accepts full responsibility for the conduct of the study, had access to the data, and controlled the decision to publish.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the Research Ethics Board at Linköping University (Dnr 2015/132-31). Participants gave informed consent to participate in the study before taking part.

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ORCID iDs

Toomas Timpka <http://orcid.org/0000-0001-6049-5402>
 Kristina Fagher <http://orcid.org/0000-0002-9524-7553>
 Jenny Jacobsson <http://orcid.org/0000-0002-1551-1722>
 Håkan Gauffin <http://orcid.org/0000-0003-3565-4461>
 Paolo Emilio Adami <http://orcid.org/0000-0001-5975-5342>
 Stéphane Bermon <http://orcid.org/0000-0002-9529-2901>

Örjan Dahlström <http://orcid.org/0000-0002-3955-0443>

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Supplementary Figure 1. Version of the LiMP questionnaire used in the study. AT, anatomy and terminology; MC, musculoskeletal conditions; DT, diagnosis and treatment.

Item 1 (MC1)

A "fractured" bone is:

- The same as a broken bone
- Worse than a broken bone
- When a bone pops through the skin
- Easier to treat than a broken bone
- I don't know

Item 2 (DT1)

All of the following statements relating to medical imaging are true EXCEPT:

- X-rays involve less radiation exposure than Magnetic Resonance Imaging (MRI)
- Ultrasound imaging can be used to diagnose Achilles tendon pain
- MRI can be used to distinguish between muscle cramp and a torn muscle
- X-rays can be safely performed on athletes younger than 18 years of age

Item 3 (AT1)

What is the name of the bone in your thigh?

- Humerus
- Radius
- Femur
- Tibia
- I don't know

Item 4 (AT2)

An Orthopedic Surgeon is:

- A doctor who cares for the heart
- A doctor who cares for ears, nose and throat
- A doctor who specializes in foot care
- A doctor who specializes in the care of bones and muscles
- I don't know

Item 5 (MC2)

What is sciatica?

- Pain in your back and leg(s) caused by hip arthritis
- Pain in your back and leg(s) caused by compression of nerve roots originating in your spine
- Severe thigh pain due to a torn muscle spasm
- Pain in your back and leg(s) due to a blood clot
- I don't know

Item 6 (AT3)

The knee is a:

- Bone
- Ligament
- Muscle
- Joint
- I don't know

Item 7 (MC3)

Arthritis is:

- A joint disorder due to inflammation of one or more joints
- Due to wear-and-tear of a joint
- A condition that develops due to an infection
- All of the above
- I don't know

Item 8 (DT2)

All of the following statements are true EXCEPT:

- A torn muscle can be treated with cold
- A muscle spasm is a less severe condition than a torn muscle
- A sprained ankle is caused by a problem with a tendon
- Massages can help to recover from a muscle spasm

Item 9 (DT3)

If you break your wrist, what might your physician give you to help you heal?

- A surgery
- A cast
- A surgery or a cast
- I don't know

Supplementary Figure 2. Sufficient musculoskeletal health literacy status according to LiMP scores (total and subthemes) displayed by Human Development Index of the athlete's home country (shaded areas show 95% confidence intervals; lines smoothed using locally estimated scatterplot smoothing [LOESS]). AT, anatomy and terminology; MC, musculoskeletal conditions; DT, diagnosis and treatment.

