Nabhan, D., Lewis, M., Taylor, D., Bahr, R., Expanding the screening toolbox to promote athlete health: how the US Olympic & Paralympic Committee screened for health problems in 940 elite athletes. *British Journal of Sports Medicine, 55*(4), 226-230. https://doi.org/10.1136/bjsports-2020-102756

Expanding the screening toolbox to promote athlete health: How the US Olympic & Paralympic Committee screened for health problems in 940 elite athletes

Dustin Nabhan, Melie Lewis, David Taylor, Roald Bahr

Research performed at United States Olympic & Paralympic Committee, Colorado Springs, Colorado

[1] Sports Medicine Division, United States Olympic & Paralympic Committee. Colorado Springs, Colorado USA

[2] US Coalition for the Prevention of Illness and Injury in Sport. Colorado Springs, Colorado USA

[3] Oslo Sports Trauma Research Centre. Oslo, Norway

The authors have no relevant financial disclosures. There was no grant support for this project.

Ethics Approval: Southern California University of Health Sciences

Corresponding Author:

Dustin Nabhan

1 Olympic Plaza

Colorado Springs CO, 80909 USA

Dustin.Nabhan@usoc.org +1 719 866 4554

Keywords: epidemiology, screening, health promotion

Word count (excluding title page, abstract, references, figures): 2404

ABSTRACT

Aim: To assess the value of including validated screening tools for allergies, anxiety, depression, sleep apnea and sleep quality into an electronic patient health history questionnaire.

Methods: In this descriptive study we reviewed electronic medical records of Olympic and Paralympic athletes who completed health screenings, which included validated screens for allergies (Allergy Questionnaire for Athletes), anxiety (GAD 2), depression (PHQ 2), sleep apnea (Berlin Questionnaire) and sleep quality (Pittsburgh Sleep Quality Index), using established criteria for a positive screen. We report the prevalence of positive tests and the associations between positive screening tools.

Results: A total of 683 Olympic and 257 Paralympic athletes (462 male, 478 female) completed the health history between May and September of 2019. At least one positive screen was reported by 37% of athletes training for the Olympics and 48% of athletes training for the Paralympics. More than 20% of all athletes screened positive for allergies and poor sleep quality. Athletes training for the Paralympics had a significantly higher percentage of positive screens for anxiety, depression, poor sleep quality and sleep apnea risk. Females had significantly more positive screens for allergy and poor sleep quality.

Conclusions: The addition of standardized screening tools to an electronic health history resulted in the identification of potential mental health, sleep and allergy problems in both Olympic and Paralympic athletes. Strong associations between mental health and sleep disorders suggest these problems should be considered together in health screening programs.

What are the new findings?	**How might it impact clinical practice in the near future?**

Including validated screening tools into an electronic health history helps identify sleep, mental health and allergies in the elite athlete population. There are strong associations between the prevalence of sleep, mental health and allergy in elite athletes.	Clinicians should include screening tools for conditions that are difficult to identify in the clinical setting into the periodic health evaluations. The identification of sleep, mental health or allergy should prompt investigation into associated conditions. This screening method supports the medical team by giving them a more specific picture of large groups. Identifying athletes with complex conditions allows clinicians to prioritize them and prepare more advanced clinical screening to those athletes with positive results.

INTRODUCTION

Health is defined as the state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.[1] Evidence-based health promotion is defined as the use of information derived from formal research and systematic investigation to identify causes and contributing factors to health needs and the most effective health promotion actions to address these in given contexts and populations.[2] Sports medicine screening programs contribute to evidence-based health promotion by identifying athletes with current health conditions, risk factors for future conditions, and serving as a portal of entry for athletes into clinical programs dedicated to health promotion.[3-5] However, to address all aspects of athlete health, the scope

of these programs must expand beyond the prevention of injuries prevention and take a holistic approach.

In elite sport, health promotion programs often include some combination of screening, monitoring, injury and illness surveillance. The use of questionnaires as part of these programs, often as a first step in a periodic health evaluation (PHE), is standard practice.[4,6,7] These questionnaires have common themes that include investigation into an athlete's previous medical history, current signs or symptoms, and family history. The goal of questionnaires is to identify current and potential health conditions in an individual; the data are then used to guide a structured physical examination, and occasionally other special tests such as ECG or laboratory studies.[3,4] Also, aggregate data can be used for research and to guide the development of more effective health promotion programs.[4,5]

However, the traditional structure of the periodic health evaluation may not capture many conditions that are difficult to diagnose in the primary care setting. There are common and clinically significant health conditions that are missed in routine clinical practice, such as anxiety, depression, allergies and sleep disorders.[8-12] Screening tools have been validated to help identify some of these conditions.[13-17] Integration of screening questionnaires into health promotion programs may result in greater capture and improved management of these conditions.[15,18-20] However, the value of including such screening tools in the periodic health evaluation has not been assessed in an elite sport setting.

Our research group developed an electronic health history questionnaire that included screening tools for mental health, sleep and allergies. We aimed to implement this questionnaire as part of a screening program for Olympic and Paralympic athletes and report the prevalence of positive findings for each screening tool and examine the associations between tools.

METHODS

Study design and participants

We performed a retrospective analysis of data collected between May 2019 and September 2019 by a web-based health history questionnaire developed for clinical use by the United States Olympic & Paralympic Committee (USOPC). Athletes who chose to participate in medical screenings at NOPC clinics, resident athletes at USOPC training centers, and athletes who

registered for international games completed a pre-participation health history questionnaire. This questionnaire was used to screen athletes for current or prior medical conditions that require treatment, to identify risk factors for injury, illness or suboptimal performance, and identify the use of medications or supplements that may place the athlete at risk for an anti-doping violation. Completed health histories are used to create patient- and team-specific dashboards to be reviewed by team clinicians as part of usual patient care, and PDFs of the questionnaire are entered in the corresponding electronic health record. Deidentified data from these questionnaires were aggregated and analyzed for the purpose of this study.

Ethics approval for the use of this data set for the purpose of this project was provided by Southern California University of Health Sciences.

This research was done without patient involvement. Patients were not invited to comment on the study design and were not consulted to develop patient relevant outcomes or interpret the results. Patients were not invited to contribute to the writing or editing of this document for readability or accuracy.

Electronic health history process

Patients were emailed a hyperlink to the health history questionnaire via an encrypted website (Qualtrics). The questionnaire included items from widely distributed health history forms, including the PPE Monograph 4th edition, the IOC Periodic Health Examination health history form, the Allergy Questionnaire for Athletes (AQUA), the Berlin Sleep Apnea Questionnaire, the Patient Health Questionaire-2 (PHQ2), the General Anxiety Disorder-2 (GAD2) and the Pittsburgh Sleep Quality Index (PSQI).[4,7,13-17] The questionnaire used embedded logic to present items relevant to the patient. Screening tools that utilized entry or exit questions such as the GAD2 and PHQ2 were incorporated with their logic to minimize questionnaire burden.

Data Analysis

Data sets were stratified by sex and sport. Screening tools were scored and dichotomized as positive or negative according to thresholds defined in the literature, with the following criteria for a positive score: AQUA≥5, Berlin ≥2, GAD2 ≥3, PHQ2≥3, PHQ 9 ≥10, PSQI ≥5.[13-17]

A chi square test of independence was used in R to determine statistically significant differences in proportions of positive screening responses in sex and Olympic vs Paralympic sport

populations. Cohens kappa was calculated in JMP 15.1 (SAS, Carey, North Carolina, USA) to evaluate the level of agreement between screening tools. Prevalence ratios were calculated in Microsoft Excel for the prevalence of being flagged for one screening tool (consequent) if positive for an alternate screening tool (antecedent), as compared to being screened positive for the consequent and negative to the antecedent.

RESULTS

Nine hundred and forty athletes (462 female and 478 male), 683 from Olympic programs and 257 Paralympic completed the health history questionnaire. The athletes represented 36 federations. The electronic health history took a median of 28 min to complete. Athlete characteristics are summarized in Table 1.

Table 1 Athlete distribution by federation.

	Olympic (N=683)		**Paralympic** (N=257)	
Sport	Male	Female	Male	Female
Archery	4	4	-	-
Athletics	113	114	40	25
Badminton	4	4	2	1
Basketball	16	14	12	12
Boccia	-	-	1	-
Boxing	5	5	-	-
Canoe-Kayak	9	8	-	-
Cycling	8	8	7	6
Diving	4	3	-	-
Equestrian	4	9	-	-
Fencing	8	9	-	-
Field Hockey	15	16	-	-
Golf	2	2	-	-
Goalball	-	-	6	6
Gymnastics	7	11	-	-
Handball	13	12	-	-
Judo	3	6	7	4
Karate	4	5	-	-
Pentathlon	2	3	-	-
Powerlifting	-	-	4	-
Rowing	11	8	-	-
Rugby 7s	8	20	12	-
Sailing	9	5	-	-
Softball	-	15	-	-
Shooting	7	11	8	4
Soccer	-	-	15	-

Swimming	19	19	15	20
Synchronized Swimming	-	6	-	-
Tennis	1	3	4	2
Taekwondo	3	4	5	2
Triathlon	3	3	-	-
Table Tennis	1	3	10	4
Volleyball	12	14	12	11
Olympic Weightlifting	1	4	-	-
Water Polo	11	11	-	-
Wrestling	11	6	-	-

Table 2 presents the proportion of positive screens for the five screening tools; 37% of athletes training for the Olympics and 48% of athletes training for the Paralympics were identified to have at least one positive screen. More than 20% of all athletes screened positive for the allergies and poor sleep quality. Athletes training for the Paralympics had a significantly higher percentage of positive screens for anxiety, depression, poor sleep quality and sleep apnea risk (chi-square, Table 2). There were also sex differences in screening tool responses, with a greater percentage of females with positive screens for allergy and poor sleep quality (Table 2).

Table 2 Prevalence of positive screening tool findings in male and female athletes training for Olympic and Paralympic Games.

	Olympic / Paralympic				**Male / Female**			
Screening Tool	Olympic (n = 683)	Paralympic (n = 257)	χ^2	p	Male (n = 477)	Female (n = 463)	χ^2	p
Allergy (AQUA)	20.6%	25.3%	2.09	0.15	16.4%	27.7%	16.86	< 0.01
Anxiety (GAD)	3.1%	7.4%	7.52	< 0.01	4.0%	4.5%	0.07	0.80
Depression (PHQ-9)	1.9%	4.7%	4.50	0.03	2.7%	2.6%	0.00	1.00
Sleep Apnea (Berlin)	3.47%	8.6%	9.94	< 0.01	5.7%	3.9%	1.25	0.26
Sleep Quality (PSQI)	23.1%	30.7%	5.33	0.02	22.2%	28.3%	4.28	0.04

There was significant overlap of positive screening tools (Figure 1). Sixty percent of all athletes did not have a positive finding, 27%% had one positive, 9% had two, 2% had three, 1% had four and 0.4% five.

ENTER FIGURE 1 HERE

Table 3 shows the level of agreement between screening tools. There were higher levels of agreement for the anxiety and depression tools than the other pairs of tools.

Table 3 Measure of agreement between screening tools.

Screening Tool		Kappa
Anxiety	Allergies	0.07 (0.02 to 0.13)
Anxiety	Sleep Quality	0.18 (0.12 to 0.24)
Anxiety	Sleep Apnea	0.25 (0.12 to 0.38)
Anxiety	Depression	0.57 (0.43 to 0.72)
Allergies	Sleep Quality	0.18 (0.11 to 0.25)
Allergies	Sleep Apnea	0.07 (0.01 to 0.13)
Allergies	Depression	0.05 (0.00 to 0.10)
Depression	Sleep Quality	0.14 (0.09 to 0.19)
Depression	Sleep Apnea	0.20 (0.07 to 0.33)
Sleep Apnea	Sleep Quality	0.17 (0.11 to 0.23)

Prevalence ratios for associations between tools showed that a positive screen for any individual tool increased the prevalence ratio for all other tools (Table 4). The magnitudes of prevalence ratios were the highest for associations between depression when positive for anxiety, depression when positive for sleep apnea, anxiety when positive for depression, and anxiety when positive for poor sleep quality.

Table 4 Prevalence ratios with 95% CI for associations between positive screening tools.

	Anxiety	**Allergy**	**Depression**	**Sleep Apnea**	**Sleep Quality**
Anxiety	-	2.0 (1.4 to 3.0)	71.3 (30.1 to 168.6)	8.2 (4.3 to 15.5)	3.6 (3.0 to 4.4)
Allergy	2.6 (1.4 to 4.8)	-	2.8 (1.3 to 6.1)	2.4 (1.3 to 4.2)	1.9 (1.5 to 2.3)
Depression	33.1 (20.6 to 53.3)	2.1 (1.3 to 3.3)	-	7.9 (4.1 to 15.2)	4.1 (3.6 to 4.8)
Sleep Apnea	8.5 (4.6 to 15.6)	1.9 (1.3 to 2.8)	9.4 (4.3 to 20.5)	-	3.2 (2.6 to 4.0)
Sleep Quality	14.0 (6.3 to 31.2)	2.0 (1.5 to 2.5)	71.2 (9.7 to 523.4)	8.2 (4.3 to 15.5)	-

*Column headings are the dependent variable for prevalence ratios, row headings the independent variable. Prevalence ratio = (Prevalence positive when row is positive)/(Prevalence positive when row negative).

DISCUSSION

The addition of validated health screening tools to a standard periodic health evaluation questionnaire resulted in the identification of either sleep, mental health, or allergy risk in 48% of athletes training for the Paralympics and 37% of athletes training for the Olympics. This a relevant finding for sports medicine clinicians, as these conditions are difficult to diagnose in the primary care setting.[8-12]

Associations between Screening Tools

The presence of any positive screen was associated with increased prevalence of other positive screens for all five tools used in this program. The cross sectional, observational study design introduces the antecedent-consequent paradox, in which we cannot make causal inferences from the data. However, clinicians should be aware that there were positive associations between all the conditions we screened for and consider this when interpreting screening data. Positive associations between tools can guide clinicians to identify associated health problems.

The associations between positive screens must be interpreted with caution due to the potential overlap in the items of the tools used in this study. We used Cohen's kappa to determine the level of agreement between tools; agreement was low for all combinations of tools except for the PHQ2 and GAD2 (kappa of 0.57). There are limitations to the use of Cohen's kappa in this study, as some conditions were common (up to 30% of Paralympians for allergies) and others rare (2% of Olympians for depression). Kappa values are be affected by differences in prevalence, with high prevalence differences diluting kappa values.[21] Therefore, it is possible that the agreement between the screening tools used in this study is higher than we reported.

The prevalence ratios with the strongest association were anxiety with depression and sleep apnea with depression and anxiety. These prevalence ratios we found suggest that the identification of one risk factor increases the probability of associated. Reciprocal relationships between sleep and immune function, sleep and mental health conditions, and immune function and mental health have been proposed, which suggest that there may be complex, interconnected pathophysiology between these conditions.[22-25] Providing optimal care to patients with these conditions should include addressing each system as a potential risk factor for the others.

Mental Health

The prevalence of mental health problems in elite athletes is unknown, however there are known relationships between mental health, performance, injury, re-injury and illness risk.[26] There

are barriers to access of mental health services in the elite athlete population, including a stigma that reduces athlete motivation to seek treatment, a lack of mental health resources, poor understanding of mental health, and poor experience interfacing with mental health providers.[27] Valid clinical tools for screening and/or diagnosing these conditions must be identified or developed so health care providers can appropriately diagnose and treat symptomatic athletes.[28]

We chose mental health screening tools for anxiety and depression that are recommended for use in the general population.[29,30] These tools, the GAD2 and PHQ2, are short questionnaires that can be expanded by survey logic to provide more comprehensive screening for athletes who appear to be at risk based on entry questions. This computer adaptive testing approach has been shown to be effective in primary care settings for depression and anxiety screening.[31]

Our findings reveal that 2.7% of athletes screened had positive flags for depression, and 4.3% of athletes had positive flags for anxiety. In comparison, screening in the general population for these disorders results in prevalence of ~8-25% for depression and ~5% for anxiety.[10,32,33] We identified 2.5 times greater prevalence of positive mental health screens in the Paralympic population as compared to the Olympic population. This finding suggests that athletes living with disability may represent a greater risk for mental health issues, a suggestion that has been previously proposed as a stereotype, but without the backing of evidence.[34] Without diagnostic confirmation, we cannot confirm that the true incidence of mental health problems is higher in the Paralympic population; however, our findings should be considered by adaptive sport organizations when developing mental health resources for their athletes.

Sleep

Sleep is essential. Sleep deprivation negatively impacts mood, cognition, metabolism and the immune system.[35] Athletes who sleep less have higher rates of injury, and there may be a relationship between injury risk and sleep deprivation; injury incidence is believed to increase during periods of high training load and less sleep.[36,37] Adults who sleep less have higher susceptibility to infection after exposure to pathogens.[38,39] Observational studies of elite athletes who sleep less have demonstrated higher illness incidence, however there is limited research on this topic outside of cross-sectional surveys.[40]

Sleep disorders are poorly identified by usual care in the primary care setting.[41] Recognition of sleep disorders can be improved when screening tools are implemented routinely.[16] Clinicians must consider both sleep quality and sleep apnea screening, as they are distinct clinical entities that must be screened for separately.[42] Many athletes have anthropometric characteristics (BMI >28 kg/m2 and neck circumference >40cm) that increase their risk for sleep apnea, which warrants special consideration for screening.[43]

A significantly higher proportion of athletes training for the Paralympic Games were flagged for sleep problems than their Olympic counterparts; 8.6% of Paralympians were identified as at risk for sleep apnea. There is a paucity of literature on sleep health in the adaptive sport population, so the causes for sleep disturbance in this population are not yet fully understood.[44] Given the importance of sleep, the strong associations we found with sleep and other clinical screening tools, and the severe potential consequences of untreated sleep apnea, this is an area that should be addressed with further research.

Allergy

Allergies are common in elite athlete populations, with a prevalence of allergic rhinitis reported to range from 13% to 41%.[15] Allergies negatively impact quality of life, physical performance, and may contribute to the development of other comorbidities.[45] Allergy screening can be expensive, requiring laboratory tests and specialty referrals. However, the use of a short questionnaire has been validated for use in athlete populations that has proven to have a high positive predictive value.[15]

The high prevalence of athletes with positive allergy screening suggests that it is reasonable to include this item into a standard screening battery. Allergy is closely linked with other conditions, such as sleep disturbance and asthma.[25] It has been previously reported that athletes with allergies may not be seeking appropriate treatment, with one study of endurance athletes showing only half of symptomatic athletes used allergy medication.[45] Untreated allergies may have long-term consequences, such as development of chronic inflammatory adaptations in the respiratory or GI tract.[46] Secondary manifestations of unidentified or untreated food allergies can lead to malnutrition due to food avoidance and increased risk of other atopic conditions such as rhinitis.[47] Some sport organizations already include more advanced allergy screening programs in their PHE, including skin reactivity tests to common

allergens.[48] More research is needed to assess the impact of robust laboratory screening as compared to screening questionnaires.

Limitations

This is a cross sectional study that compares the point prevalence of positive findings for screening tools that represent a documented risk for health conditions. The reporting method is athlete self-report via questionnaire, which may be vulnerable to selective reporting and recall bias. The questionnaires used describe point prevalence only. In studies using patient self-report through written surveys, there may be a percentage of participants who choose to not respond accurately.[49] Some screening tools are designed to identify recent or current symptoms/behaviors; for example, GAD asks about anxiety symptoms present in the last 2 weeks. No outcomes were assessed in the study, there is an assumption that the identification of a positive screening tool in an individual is correlated to true diagnostic outcomes. Future study designs should include prospective reporting of health conditions diagnosed and compare these to the screening tool results.

Conclusion

The inclusion of standardized screening tools in an electronic health history resulted in the identification of potential mental health, sleep and allergy problems in both Olympic and Paralympic athletes. Strong associations between anxiety, depression and sleep disorders highlight the importance of comprehensive screening programs to identify risk factors for these conditions.

Figure 1 Relationship between positive screening tools. Grey indicates athletes with negative screening for all tools.

Competing Interests

The authors have no competing interests.

Acknowledgements

There are no acknowledgements.

Contributorship

DN, DT and RB conceived and planned the project. DN, ML collected data for the project and completed data analysis. All authors participated in writing the manuscript. DN and RB directed the project.

Funding

No external funding was used for this project.

Ethics Approval

This project was approved by the ethics board of Southern California University of Health Sciences.

Data Sharing

This is a retrospective review of medical records of a sensitive patient population, and therefore it is not appropriate to share raw data. However compiled data is available in the supplementary tables.

Patient Involvement

There was no patient involvement in the research design.

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