Differences in career longevity before and after implementation of the Women's Tennis Association Tour Age Eligibility Rule and Player Development Programmes: a 25-year study

Carol L Otis,[1] Brian Hainline ,[2] Christopher Harwood,[3] Neeru A Jayanthi,[4] Rick Jensen,[5] Ashley Keber,[6] Emily Kroshus,[7,8] Thomas Livengood,[6] Kathleen Stroia,[6] Ann Quinn,[9] Sarka Vitkova,[6] Stephanie A Kliethermes [10]

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For numbered affiliations see end of article.

Correspondence to
Dr Stephanie A Kliethermes, Department of Orthopedics and Rehabilitation, University of Wisconsin-Madison, Madison, Wisconsin, USA; kliethermes@ortho.wisc.edu

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ABSTRACT

Objectives To assess differences in career longevity, as a potential marker of athlete well-being, before and after the 1995 implementation of the Women's Tennis Association (WTA) Age Eligibility Rule (AER) and Player Development Programmes (PDP), which focused on organisational, physical and psychosocial education, skill building and support for adolescent athletes (≤17 years).

Methods Career longevity data were collected through 2019 on adolescent players who began professional tournament play between 1970 and 2014 and reached a WTA singles ranking of 1–150 for a minimum of 1 week during their careers. Players were separated into pre-AER/PDP and post-AER/PDP groups, consisting of those who played their first professional events (FPE) before or after 1 January 1995. Measures of career longevity included career duration and premature retirement.

Results Eight-hundred and eleven players were included in this study (51% pre-AER/PDP). The median career duration was 14.2 years for the post-AER/PDP group compared with 12.1 years for the pre-AER/PDP group (p<0.001). Moreover, post-AER/PDP players had higher probabilities of 10-year and 15-year careers compared with pre-AER/PDP players. After adjusting for age at FPE, athletes in the pre-AER/PDP group had an increased risk of shorter career duration (HR 1.55; 95% CI 1.31 to 1.83) and increased odds of premature retirement (OR 5.39; 95% CI 2.28 to 12.75) than athletes in the post-AER/PDP group.

Conclusions Adolescent athletes participating on the WTA after the combined AER/PDP initiative had longer career durations, higher probabilities of 10-year and 15-year careers, and decreased risk of premature retirement compared with those participating prior to AER/PDP. Organisational practices that encompass both education and competition regulation can positively affect career longevity related to improving athlete well-being.

INTRODUCTION

Women's professional tennis is a potentially lucrative sport, with a history of adolescent phenoms competing with more seasoned players. Despite high profile instances of adolescent competitive success, ample literature documents potential risks for these young professional athletes as they contend with sport stressors and an international media spotlight before reaching their full physical, skeletal and socioemotional maturity. Physical risks include acute and chronic injury[1–6]; emotional and psychological risks including stress, depression and anxiety,[7–10] 'burnout',[11–15] exploitation, harassment, vulnerability to abuse[16] and eating disorders.[17–21] Potential consequences of these physical and psychosocial risks include shorter career durations and premature sport retirement.[22 23]

In 1994, the Women's Tennis Association (WTA) commissioned an international Player Development Advisory Panel (Panel) of voluntary and independent sports science and medicine experts. The Panel's charge was to review extant research and provide evidence-based recommendations for organisational changes that could promote career longevity (ie, via minimising identified stressors and reducing the physical, psychological and developmental risks of women's professional tennis—hereinafter referred to by the term 'well-being').[24] In 1995, the WTA provided an athlete development oriented policy-level intervention via the modification of their Age Eligibility Rule (AER) and implementation of new mandatory Player Development Programmes (PDP). These simultaneous changes to policy and practice allowed a phased-in approach of professional tennis participation for players aged 14–17 years in accordance with their age, ranking and the skills gained from participation in PDP.[22 25 26] PDP includes organisational, physical and psychosocial education, skill building (eg, media training), and monitoring and support mechanisms (eg, mentoring and annual physical examinations). With the goal of creating a safe and healthy environment, some elements of the PDP were targeted at members of the athletes' support system (ie, coaches, parents). This included parent and coach education, coach registration, and a code of ethics for player support team members (parent, coaches, agents, etc). Player surveys conducted in 2004 and 2015 (as part of longitudinal panel-led internal reviews) have been used to identify and meet evolving player needs, as part of ongoing quality improvement efforts. Survey feedback identified new top stressors (eg, self-expectations and finances) and new player priorities and needs (ie, safeguarding and monitoring psychological health).[27] Based on panel recommendations from these data, key changes to the WTA's approach since 2004 have included: refining the AER (ie,

allowing more merit-based playing opportunities) and PDP (ie, expanding mental health and financial planning resources); and increasing the reach and execution of PDP by enhanced WTA staffing and staff training.

As guided by the panel, steps taken by the WTA to address issues of player well-being and career longevity are theoretically consistent with leading models for positive youth development. Based on a qualitative meta-synthesis of strategies to support healthy, developmentally appropriate sport participation, Holt *et al* articulated a model of positive youth development through sport.[22] This model draws attention to key levers for intervention: (1) distal ecological systems (ie, organisational policy), (2) implicit processes that result from a positive sport climate (ie, coaching) and (3) explicit processes as a result of life skills programming. The best athlete outcomes are expected when all three model components are implemented. The question of how to support developmentally appropriate, healthy and sustained elite sport participation is not unique to professional tennis.[23] However, efforts to address this problem in elite tennis settings may prove instructive for others involved in promoting well-being among elite adolescent and young adult athletes.[27]

A 2006 analysis of career longevity data 10 years after WTA's 1995 adoption of the AER and PDP showed longer career durations and lower rates of premature retirement compared with the cohort of players who began their professional careers prior to 1995.[27] However these analyses were limited by a large amount of censored data (ie, careers extending past 2004), less available data to assess probabilities of 10-year and 15-year careers, and the inability to fully assess premature retirement due to numerous players competing under the age of 22. Addressing these limitations by allowing post-AER/PDP careers to mature past age 22 and reducing the amount of censored data, the goal of this study was to further assess differences in career longevity between two different cohorts of top 150 ranked players who played their first professional event under the age of 18 before and after the WTA modified the AER and implemented PDP in 1995.

METHODS

Data source

Player data from 1970 to 2004 were initially pulled for the 10-year review[27]; those data were accessed for this study. Additionally, data for players that started their careers between 2004 and 2014 were pulled from the WTA computer ranking system and database (Interactive Computer Applications Development, Inc —a Sybase-based system) with their career data allowed to mature through 2019.

Study population

Athletes were eligible for inclusion in the study if (1) they were under the age of 18 years when they first played in a WTA professional event and (2) they reached a WTA singles ranking of 1–150 for a minimum of 1 week at some point during their careers. Eligible players were then separated into two groups based on implementation of the AER and PDP in 1995. More information on the AER and PDP programmes can be found in online supplemental material 1. Eligible players who played their first professional events between 1 January 1970 and 31 December 1994 were classified in the pre-AER/PDP group and those who played their first professional events between 1 January 1995 and 31 December 2019 were classified in the post-AER/PDP group. Additional participant characteristics extracted from the database include the ages at which the athletes played their first and last professional events, the (calendar) year of the player's first time on tour, and whether the player is currently active or retired.

Age groups in this study are categorised as ≤14, 15, 16 and 17. Twenty-nine players in the pre-AER/PDP group played under the age of 14. Since the modification of the AER and inception of PDP in 1995, players under 14 years old are no longer eligible to play professionally, although one post-AER/PDP player played at 13.9 years of age due to an administrative error.

Career longevity outcomes

Career longevity was measured using two metrics: career duration and premature retirement. Career duration was defined as the time period between the singles main draw start date of a player's first professional event and her last singles or doubles professional event, excluding periods of inactivity (ie, time period in which player was unranked in singles and doubles) of 52 weeks or more. Both an athlete's actual career duration and their probability of a 10-year and 15-year career were considered. Premature retirement was defined as a player retiring from the sport before her 22nd birthday.

Statistical analysis

Standard descriptive statistics were used to describe study population characteristics overall and by AER/PDP group. Means and standard deviations (SD) or medians and interquartile ranges (IQR) were used for continuous variables as appropriate and frequencies and percentages described categorical variables. Kaplan-Meier survival methods were used to assess associations between AER/PDP group and career duration while accounting for censored data (eg, athletes still active at time of final data collection, 31 December 2019 and therefore without complete career duration data). Survival curves between the pre-AER/PDP and post-AER/PDP groups were estimated via the Kaplan-Meier estimator and survival probabilities between the two groups were compared via a log-rank test. Life tables were used to estimate the 10-year and 15-year career duration probabilities for each group and significant differences were assumed for non-overlapping 95% CIs.

Cox proportional hazard regression models were built to assess the univariable associations of AER/PDP group, calendar year of first professional event, and player age at first professional event with career duration. In an attempt to control for omitted-variable bias, a multivariable model inclusive of AER/PDP group and player age at first professional event (as a continuous variable) was built. Calendar year of first professional event was not included in the multivariable model due to collinearity of this variable with the AER/PDP variable (ie, if we know the value of one variable, we also know the value of the other variable). Lastly, premature retirement rates were computed from the raw data of the pre-AER/PDP and post-AER/PDP groups. Additional univariable and multivariable firth binary logistic regression analyses were used to compare premature retirement rates between the two AER/PDP groups. Hazard ratios (HR) and odds ratios (OR), as appropriate, along with their corresponding 95% confidence intervals (CI) are provided for all models. SAS V.9.4 (SAS institutes) and R: A Language and Environment for Statistical Computing (V.4.1.1; R Core Team; https://www.R-project.org/) were used for all analyses.

RESULTS

A total of 811 athletes were included in this study with 414 (51%) classified in the pre-AER/PDP group and 397 (49%)

Table 1 Study population characteristics

Variable	Pre-AER/PDP (N=414)	Post-AER/PDP (N=397)	Overall (N=811)
Age at first professional event, mean (SD)	15.23 (1.14)	14.84 (0.92)	15.04 (1.06)
Age at last professional event, mean (SD)	27.89 (5.01)	28.06 (3.67)	27.98 (4.40)
Inactivity greater than 1 year, n (%)	76 (18)	138 (35)	214 (26)
Length of inactivity*, median (IQR)	1.68 (1.19–2.68)	1.71 (1.24–2.85)	1.69 (1.23, 2.76)
Currently active, %	1	42	21
Premature retirement, %	7	2	4

*Length of inactivity among players who experienced a period of inactivity greater than 1 year during their career.
AER/PDP, Age Eligibility Rule and Player Development Programs.

classified in the post-AER/PDP group. Characteristics of the study population, overall and by AER/PDP group, are provided in table 1. The average age of the athlete's first professional event was 15.04 (1.06) years and the average age of their last professional event was 27.98 (4.40) years. Twenty-one per cent of the study population is currently active, with 4 (1%) of those players belonging to the pre-AER/PDP group.

Career duration

The median career duration was 14.2 (95% CI 13.6 to 15.0) years for the post-AER/PDP group compared with 12.1 (95% CI 11.3 to 12.6) years for the pre-AER/PDP group (p<0.001; table 2, figure 1). When considering age at first professional event, the post-AER/PDP group had significantly longer median career durations than the pre-AER/PDP group at age groups ≤14 and 15 (p<0.001 and p=0.02, respectively); however, no significant differences in median career duration were identified for the 16 and 17 years age groups (p=0.17 and p=0.07, respectively) (table 2, online supplemental figures 1–4). The probability of a 10-year and 15-year career was greater for the post-AER/PDP group than the pre-AER/PDP group (10 years: 81% (95% CI 77% to 84%) vs 65% (95% CI 60% to 69%); 15 years: 44% (95% CI 38% to 50%) vs 22% (95% CI 19% to 27%; respectively). These trends additionally hold for the various ages at which players participated in their first professional event; however, were not significantly different at the older age groups (table 2).

Univariable cox proportional hazards models suggest calendar year of first professional event, age at first professional event and AER/PDP group were all significantly associated with career duration (table 3). For every calendar year increase (between 1970 and 2019), the risk of a shorter career duration decreased by approximately 3% (HR 0.97, 95% CI 0.96 to 0.98). Athletes, who played their first professional event at a later age, were more likely to have shorter career durations than those who played their first professional event at an earlier age (HR 1.26, 95% CI 1.17 to 1.37). Similarly, athletes participating in the WTA prior to the implementation of the AER/PDP had a 68% increased risk of a shorter career duration than those who first participated postimplementation of AER/PDP (HR 1.68, 95% CI 1.43 to 1.98). After adjusting for age of first professional event, athletes in the pre-AER/PDP group still had a higher risk of shorter career duration than athletes in the post-AER/PDP group (adjusted HR 1.55; 95% CI 1.31 to 1.83).

Premature retirement

7.25% of athletes in the pre-AER/PDP group prematurely retired compared with 1.51% in the post-AER/PDP group (p<0.001, table 4). In the post-AER/PDP group, 1.26% of players ≤14 years of age at their first professional event prematurely retired. The percentage of athletes prematurely retiring steadily decreased as their age at first professional event increased. Similarly, in the pre-AER/PDP group, the highest percentage of premature retirement was seen among those athletes who played their first professional event at the age groups of ≤14 (2.90%), followed by 15 (2.17%), 16 (1.69%) and then 17 (0.48%) years.

Based on univariable logistic regression results, the odds of premature retirement in the pre-AER/PDP group were 5.09 (95% CI 2.10 to 12.37) times greater than the odds of premature retirement in the post-AER/PDP group (table 5). The odds of premature retirement decreased by approximately 7% over time (OR 0.93, 95% CI 0.89 to 0.97). Univariably, no significant

Table 2 Career duration data, pre-AER/PDP versus post-AER/PDP overall and by age at first professional event (FPE)

			Career duration probability	
Age at FPE	AER/PDP group	Median career duration (years)	Probability of 10-year career duration (95% CI)	Probability of 15-year career duration (95% CI)
Overall	Pre-AER/PDP (N=414)	12.1 (11.3, 12.6)*	65% (60% to 69%)*	23% (19% to 27%)*
	Post-AER/PDP (N=397)	14.2 (13.6, 15.0)	81% (77% to 84%)	44% (38% to 50%)
≤14	Pre-AER/PDP (N=103)	12.9 (12.2, 14.1)*	70% (60% to 78%)	28% (20% to 37%)*
	Post-AER/PDP (N=178)	15.5 (14.2, 17.6)	85% (78% to 89%)	52% (43% to 60%)
15	Pre-AER/PDP (N=135)	12.2 (11.2, 13.2)	68% (60% to 76%)	24% (16% to 30%)*
	Post-AER/PDP (N=132)	13.8 (13.0, 14.9)	81% (73% to 87%)	41% (31% to 50%)
16	Pre-AER/PDP (N=120)	11.4 (10.4, 12.4)	60% (51% to 68%)	23% (15% to 29%)
	Post-AER/PDP (N=60)	12.6 (10.7, 14.8)	74% (62% to 85%)	29% (15% to 42%)
17	Pre-AER/PDP (N=56)	10.2 (9.0, 12.1)	52% (38% to 64%)	11% (4% to 20%)
	Post-AER/PDP (N=27)	12.1 (9.9, 15.7)	69% (48% to 83%)	38% (14% to 56%)

*Represents significant differences between pre-AER/PDP and post-AER/PDP groups in median career duration or 10-year and 15-year career duration probabilities based on non-overlapping 95% CIs.
AER/PDP, Age Eligibility Rule and Player Development Programmes.

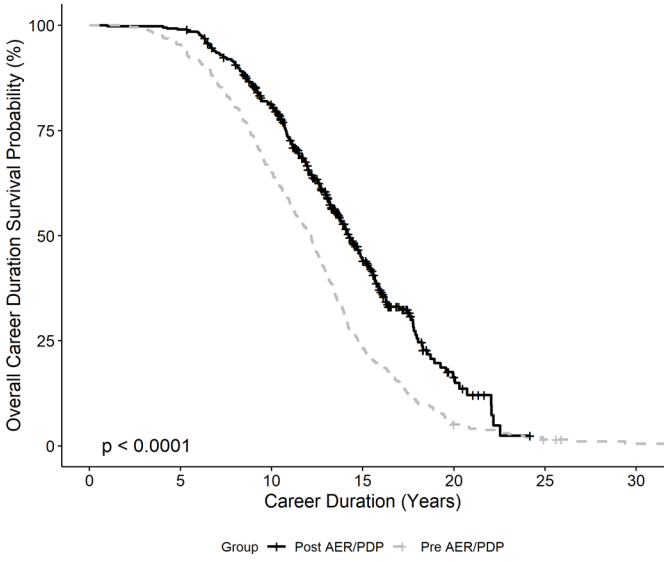

Figure 1 Kaplan-Meier career duration survival curves by AER/PDP group (n=811). AER, Age Eligibility Rule; PDP, Player Development Programmes.

association was identified between age at first professional event and premature retirement (OR 0.76, 95% CI 0.55 to 1.05; p=0.10). After adjusting for age at first professional event, the odds of premature retirement remained greater in the pre-AER/PDP group as compared with the post-AER/PDP (OR 5.39; 95% CI 2.28 to 12.75; p<0.001).

DISCUSSION

Concerns about premature sport retirement of adolescent athletes due to burnout and injury led the WTA to commission an advisory panel of independent scientific experts, and ultimately led to adopting their recommendations of an evolving theoretically consistent, multilevel strategy for supporting the physical, emotional, psychosocial and developmental well-being of players. Since 1995, the WTA has included age-related organisational policy and regulations, linked with explicit required programming. Such programming encompasses organisational, physical and psychosocial education and safety support and monitoring for adolescent athletes, and training and code of ethics guidelines for their player support teams (eg, parents, agents and coaches). The goal of this study was to assess differences in player career longevity, one potential marker of overall athlete well-being, prior to and postadoption of the WTA AER and PDP. This study provides evidence of the potential effectiveness of this approach. All three markers of career longevity in professional tennis—increased median career duration; increased probability of 10 years and 15 years career durations; and decreased premature retirement rates—have improved for the cohort of top ranked adolescent players who began playing after the WTA modified the AER and implemented PDP in 1995. These findings are consistent with analyses of a more limited subset of data conducted 10 years after AER and PDP adoption.[27] Premature retirements for the post-AER/PDP group remained low in the updated 25 year analysis (1.5% compared with <1% for the 10 year analysis); and with more complete data, the median career length post-AER/PDP implementation decreased from 15.4 years to 14.2 years in the 10-year and 25-year analyses, respectively.

This study does not disentangle the relative contribution to career longevity of age-related organisational policy (ie, AER) and player and other stakeholder education and support (ie, PDP). Rather, these are viewed as necessary components of a multilevel approach to intervention, consistent with Holt and colleague's model for positive youth development through sport,[22] as well as other emergent multi-level frameworks for supporting athlete well-being.[28] Ongoing quality improvement efforts (eg, player surveys, independent expert input) have allowed the WTA to determine whether their approach is acceptable and has evidence of effectiveness,[27] and to adjust the AER and PDP as indicated. As other sport federations consider their own approaches to intervention, a commitment to ongoing quality improvement processes is recommended to ensure organisational policy, education and other strategies can be adapted to meet evolving athlete needs.

Governing bodies across levels of sport, from grassroots to elite juniors to the professional levels, should work together in adopting and ensuring robust implementation of age-related organisational policies that intentionally encompass components of education and competition regulation under the guidance of clinical youth development advisors. This multifaceted policy model can facilitate mobility and stability for those athletes that

Table 4 Percentage rates of premature retirements as of 31 December 2019 of pre-AER/PDP versus post-AER/PDP groups, by age at first professional event

Age at first professional event	AER/PDP group	% retired before 22 years old	P value*
Overall	Pre-AER/PDP (N=414)	7.25	<0.001
Overall	Post-AER/PDP (N=397)	1.51	
≤14	Pre-AER/PDP (N=103)	2.90	0.004
≤14	Post-AER/PDP (N=178)	1.26	
15	Pre-AER/PDP (N=135)	2.17	0.02
15	Post-AER/PDP (N=132)	0.25	
16	Pre-AER/PDP (N=120)	1.69	0.10
16	Post-AER/PDP (N=60)	0.00	
17	Pre-AER/PDP (N=56)	0.48	0.55
17	Post-AER/PDP (N=27)	0.00	

*P values based on Fisher's exact test.
AER/PDP, Age Eligibility Rule and Player Development Programs.

Table 3 Univariable associations with career duration

Variable	HR (95% CI)	P value
Calendar year of FPE	0.97 (0.96 to 0.98)	<0.001
Age at FPE	1.26 (1.17 to 1.37)	<0.001
AER/PDP group*	1.68 (1.43 to 1.98)	<0.001

*Reference level=post-AER/PDP group.
AER/PDP, Age Eligibility Rule and Player Development Programmes; FPE, first professional event.

Table 5 Univariable logistic regression results for associations with premature retirement

Variable	OR	95% CI	P value
AER/PDP*	5.09	2.10 to 12.37	<0.001
Calendar year at FPE	0.93	0.89 to 0.97	<0.001
Age at FPE	0.76	0.55 to 1.05	0.10

*Reference level=post-AER/PDP group.
.AER/PDP, Age Eligibility Rule and Player Development Programmes; FPE, first professional event.

progress to the highest level of competition. Specifically, organisations should consider exposing athletes as early as possible to PDP that are developmentally appropriate and specific to the sporting environment. Promoting athlete development literacy by requiring PDP in the early stages of an adolescent player's career provides them tools to better manage the identified stressors and risks that accompany the demands and obligations of professional sports. Such an approach has the potential to maximise the success of both individual athletes and the associated organisation that provides them a healthy and safe environment to compete.

Limitations

Despite the additional years of follow-up data, career longevity data were only partly observable for some players whose careers were not completed at the time of data collection; therefore, career longevity data contained censored information that had to be accounted for in modelling. However, the expansion of this dataset to 25 years allowed for analysis of more complete career durations in the post-AER/PDP group and the estimates remained relatively consistent with the 10-year results. Importantly, we are unable to determine whether the difference in career longevity is directly attributable to WTA interventions (ie, AER and PDP) or due to external changes (eg, changes in training patterns, improvements in prize money, advances in medical care). Because of the intention and content of the combined and phased-in AER/PDP initiative for adolescent athletes, metrics of career longevity were considered a marker for athlete well-being. However, direct and longitudinal assessment of athlete well-being and mental health related to the AER/PDP is an important area of future work. AER/PDP alone, and AER/PDP after adjusting for age at first professional event, was significantly associated with longer career durations, but it is possible that other variables not assessed could additionally contribute to the longevity of player careers. A greater proportion of post-AER/PDP athletes had periods of inactivity greater than 1 year. It is plausible that different reasons for inactivity could impact career duration (eg, maternity leave, extended time off for self-care, injury recovery). However, we did not capture reasons for periods of inactivity and thus cannot deduce the potential influence of these periods of inactivity on career duration. Despite this limitation, among those who had periods of inactivity, the median period of inactivity was very similar between the two groups. Additionally, data are not available on the extent to which individual athletes or their support team engaged with PDP programmes. It is likely this intention-to-treat analysis biases results towards the null; further research is needed to understand individual experiences with PDP implementation and direct assessment of well-being. Finally, while the WTA annually reviews the AER and PDP and has made modifications over time, we were unable to directly account for and assess the impact of any modifications of the AER/PDP on career longevity, instead we looked solely at preimplementation and postimplementation of AER/PDP.

CONCLUSIONS

Determining how to support safe and healthy elite sport participation of adolescent athletes, one key metric of which is career longevity, is a priority of major international sport governing bodies.[23] This study provides evidence that a multilevel approach to intervention focused on organisational, physical and psychosocial education and skill building is associated with increased career longevity. One multilevel approach includes: sport-relevant age-related policy regulations, mandatory athlete skill building, support and training programmes explicitly targeted to adolescent athletes new to the WTA Tour, and support training requirements for all key stakeholders. While further study is needed to determine causality, this model may provide a guide for other sport governing bodies as they seek to identify approaches to intervention to support athlete well-being.

Key messages

What is already known on this topic?

- Adolescent elite athletes are exposed to unique stressors that put them at physical, emotional and psychosocial risk.

What this study adds?

- Since the modification of the WTA Age Eligibility Rule (AER) and implementation of Player Development Programmes (PDP) in 1995, median career durations and the probability of having 10-year and 15-year careers have increased for women professional tennis players.
- Premature retirement rates were significantly lower in players participating on the WTA Tour after the modification of the AER and implementation of the PDP in 1995 compared with those participating prior.

How this study might affect research, practice of policy?

- Sports organisations should consider multilevel interventions aimed towards players and key stakeholders (ie, coaches, agents, parents) inclusive of organisational policy (ie, age regulations, code of conduct), physical and psychosocial health screening, and educational initiatives that address identified athlete stressors (eg, managing self-expectations, finance, competition and media).
- A longitudinal approach to measuring the impact of organisational interventions on elite athlete well-being (or proxies for well-being, such as career longevity) can lead to ongoing and iterative clinical practice improvements.

Author affiliations
[1]Unaffiliated, Delray Beach, Florida, USA
[2]National Collegiate Athletic Association (NCAA), Indianapolis, Indiana, USA
[3]Exercise Science, Loughborough University, Loughborough, UK
[4]Sports Medicine Center, Emory University, Atlanta, Georgia, USA
[5]Rick Jensen's Performance Center, Aliso Viejo, California, USA
[6]WTA Tour, St. Petersburg, Florida, USA
[7]Department of Pediatrics, University of Washington, Seattle, Washington, USA
[8]Center for Child Health, Behavior and Development, Seattle Children's Research Institute, Seattle, Washington, USA
[9]Quintessential Edge, Blackburn, Victoria, Australia
[10]Department of Orthopedics and Rehabilitation, University of Wisconsin-Madison, Madison, Wisconsin, USA

Twitter Stephanie A Kliethermes @stephklie2

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ORCID iDs
Brian Hainline http://orcid.org/0000-0002-0233-2434
Stephanie A Kliethermes http://orcid.org/0000-0001-9756-7406

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