Effects of pre-session well-being perception on internal training load in female volleyball players.

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Presession Well-Being Perception Affects Female Volleyball Players' ITL According to Session-RPE But Not by Edwards' Method

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Purpose: To evaluate if the internal training load (ITL; Edwards' heart rate [HR]-based and session-rate of perceived exertion [RPE] methods) is affected by the presession well-being perception, age, and position in elite (ie, Serie A2) female volleyball training. ***Methods:*** Twelve female elite volleyball players (age: 22 [4] y, height: 1.80 [0.06] m, body mass: 74.1 [4.3] kg) were monitored using a HR monitor during 32 team training sessions (duration: 1:36:12 [0:22:24], in h:min:s). Linear mixed-effects models were applied to evaluate if well-being perception (ie, perceived sleep quality/disorders, stress level, fatigue, and delayed onset muscle soreness) may affect ITL depending on age and tactical positions. ***Results:*** Presession perceived fatigue influenced ITL according to the session-RPE ($P = .032$) but not by the Edwards' method. Age was inversely correlated to Edwards' ($P < .001$) and directly correlated to the session-RPE ($P = .027$). Finally, central blockers experienced a higher training load than hitters ($P < .001$) and liberos ($P < .001$) for Edwards' as well as higher than hitters ($P < .001$), liberos ($P = .003$), and setters ($P = .008$) for the session-RPE. ***Conclusions:*** Findings indicated that female volleyball players' perceived ITL is influenced by the presession well-being status, age, and position. Therefore, coaches can benefit from this information to specifically predict players' ITL in relation to the individual characteristics.

Keywords: women volleyball, perceived exertion, team sports, heart rate monitoring, Hooper's index

To elicit peak performance in sports, training programs should be carefully developed to produce the desired physiological adaptations. In particular, the physical internal training load (ITL) is one of the parameters that is controlled to elicit the desiderate workout response. As a consequence, ITL can be considered as the psychophysiological response to the external training load and can be used as the primary outcome when monitoring athletes.[1]

Rate of perceived exertion (RPE) and the session-RPE (ie, the duration of training session multiplied for RPE) have been proven to be accurate, valid, simple, and inexpensive tools to quantify ITL in team sports.[1–4] In particular, the CR-10 Borg scale modified by Foster has been commonly used to measure RPE in sports,[5] whereas the Edwards' heart rate (HR)-based method resulted in being the most adopted reference criterion.[3,6]

Although ITL has been extensively studied in invasion team sports (eg, soccer,[1] American football,[7] and basketball[6]), it has been less considered in net team sports, such as volleyball.[8,9] Due to its intermittent nature, volleyball is characterized by short duration and high-intensity and explosive efforts.[10–12] From a technical and tactical point of view and compared with the males' performance, female volleyball players used to perform less efficient receptions, less powerful attacks, and longer rallies. Moreover, female performance has a higher occurrence of digs, less jump serves, more jump float, and float serves with respect to the men's counterpart.[13] These characteristics would require an ecological quantification of the ITL. In this scenario, session-RPE was used to describe and analyze the distribution of ITL throughout the whole training season, on a daily and a weekly basis, in preparatory, regular, and congested weeks, to provide essential information about the planning and organization of training sessions.[14] Session-RPE was also demonstrated to be a valuable method for monitoring ITL in both genders and different competition levels (ie, amateur and elite) in net team sports, such as beach volleyball.[9] Nevertheless, differences in relationship between session-RPE and Edwards' HR-based method emerged in relation to types of training sessions.[3,9] Specifically, very large correlations have been reported for conditioning training in beach volleyball[9] and youth basketball,[3] while different scenarios emerged for the technical and tactical training sessions. In fact, for these last types of training sessions, strong correlation occurred only in basketball,[3] whereas they were only moderate in beach volleyball.[9] However, regardless of specific differences for types of training sessions, genders, and competition levels, the relationship between session-RPE and Edwards' HR-based method resulted in highly satisfactory monitoring of ITL in team sport.[1–3,6,9]

Even if the RPE score is mainly linked to physiological variables, such as HR, ventilation, respiratory rate, oxygen uptake, and blood lactate concentrations,[15] psychological factors also appear to be correlated. Indeed, impaired psychological well-being factors (ie, stress, anxiety, and emotional response) can negatively affect readiness to train and perform in competition,[16] or influence acute neuromuscular performance and hormonal concentration in elite female volleyball players.[17] Nevertheless, controversial results emerged for the relationship between session-RPE and well-being scores (ie, Hooper's index [HI]) or delayed onset muscle soreness (DOMS).[18] In fact, despite the ITL quantified with the session-RPE method results related to perceived presession muscle soreness both in American football[7] and soccer players,[19] for the latter sample of athletes, only partial relationships with the well-being scores (ie, stress, sleep, and fatigue factors) emerged,[19] especially during the weeks when 2 official matches were played. Yet no effect of the HI variations on RPE during a 10-minute submaximal exercise training session was highlighted.[20]

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In volleyball, age was reported to influence technical execution and tactical efficacy[21] on the one hand and mood state on the other hand.[11] In fact, despite that mood state was reported to be relatively stable regardless of changes in ITL, it appears to be affected by the experience of the athletes with a higher total mood disturbance in the younger players.[11] In professional male players, moderate-to-strong relationships occurred between HI and acute and chronic training load, especially in the second third of the season.[8] In particular, poor sleep, stress, perceived fatigue, and DOMS were reported to be highly correlated to RPE, although no internal or external training load quantification was assessed in terms of HR, accelerometer-based metrics, or tactical positions. However, to our knowledge, no study has investigated the relationship between well-being and training load on female volleyball players. In addition, differences in the playing demands, physical load, and player's characteristics between positions[12,22] need to be taken into account when analyzing ITL in volleyball. Thus, the aim of this study was to evaluate if the perceived training load (ie, Edwards' values and session-RPE) can be affected by the ~~presession~~ well-being perception in elite (ie, Serie A2) volleyball players, in relation to different ages and position roles.

Methods

Subjects

A convenience sample of 12 female elite volleyball players (mean [SD]; age: 22 [4] y, height: 1.80 [0.06] m, body mass: 74.1 [4.3] kg), members of a team competing in the 2019–2020 Italian Serie A2 (ie, the second National Senior Division) volleyball championship, participated in this study. The inclusion criteria for participating in this study were as follows: (1) at least 8 years of volleyball training experience; (2) at least 2 previous years of volleyball training experience consisting in a minimum of 4 to a maximum of 7 weekly training sessions for 90 to 180 minutes; and (3) players~~'~~ should have participated in more than 80% of the weekly training sessions. The players were classified in relation to the following tactical roles as hitters (n = 3), liberos (n = 2), central blockers (n = 3), opposites (n = 2), and setters (n = 2). Before the data collection, the institutional review board of the University of Turin approved this study, and an informed consent regarding the potential risks and benefits associated with participation has been signed by each participant in the study.

Design

An ecological longitudinal approach (ie, the training was exclusively planned by the technical staff of the team and it was never influenced by the researchers) was adopted to collect data during in-season sessions. Each training week included 5 to 6 field-training and 2 weight-training sessions. The typical organization of the training week is represented in Figure 1. The players were monitored over 16 weeks, including 32 training sessions from October 2019 to February 2020. To avoid the technical error of measurement, the adopted RPE and well-being scales were familiarized by players for 2 weeks (before the data collection) under the researchers' supervision. All the answers of RPE and well-being scales were recorded individually and collected by the same researcher.

Methodology

Well-Being. Hooper's index is widely used in volleyball[8,14] to self-report the well-being status. Approximately 20 minutes before each training session, each player was asked to rate her perceived sleep quality, stress level, fatigue, and DOMS.[18] The sum of these 4 subjective ratings, using a scale ranging from a minimum of 1 (very very low-or-good) to a maximum of 7 (very very high-or-bad), allows detecting individual well-being status before performing the training session.

Internal Training Load. The HR response was recorded every 1 second using Polar H10 (Polar Electro Oy, Kempele, Finland). HR monitors with transmitter belts placed on players' chest bands and connected to a wireless mobile tablet (I-pad Air 1; Apple, Infinite Loop, Cupertino, CA) by means of a Bluetooth connection. According ~~to the literature,~~[2] the Edwards' HR-based method[23] has been considered as a reference criterion to verify the validity of the session-RPE to quantify ITL during the sessions. Specifically, in the Edwards' HR method, individual ITLs were obtained by expressing the players' HR responses as percentages of their estimated maximal HR (ie, $HR_{max} = 220 - age$), multiplying the accumulated time (ie, in minutes) in 5 HR zones of individual HR_{max} for the corresponding coefficient (ie, 50%–60% = 1; 60%–70% = 2; 70%–80% = 3; 80%–90% = 4; 90%–100% = 5) and then summing the 5 scores.

The CR-10 Borg scale modified by Foster et al[5] was used to monitor the RPE of the players after each training session. In particular, the RPE scores were recorded approximately 20 minutes after each session, in response to the question "how was your workout?" The scale varied between 0 (rest) and 10 (maximal), and it was applied individually in each training session. According to Foster et al,[5] players' session-RPE values were obtained by multiplying each player's RPE value for the corresponding total session duration (expressed in minutes).

Statistical Analysis

Descriptive data (means and 95% confidence interval [CI]) of the players' well-being and ITLs (ie, session-RPE and Edwards' methods) were reported in relation to the players' tactical position. Successively, a series of linear mixed-effects model (LMM) was

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Morning	**Rest**	**Gym**	**Technical exercises** Low volume Low intensity	**Rest**	**Gym**	**Tactical full squad (6v6)** Low volume Low intensity	**Game**
Afternoon	**Rest**	**Technical exercises** Low volume Low intensity	**Tactical full squad (6v6)*** High volume High intensity	**Tactical full squad (6v6)*** High volume High intensity	**Tactical full squad (6v6)** Low volume Low intensity	**Rest**	

Figure 1 — Typical organization of the training week during the competitive season. ITL indicates internal training load; RPE, rate of perceived exertion. *ITL, both subjective (RPE) and objective (heart rate), and well-being status monitoring.

applied to determine the relationship between well-being and ITLs (ie, Edwards' ITL and session-RPE). As younger players were reported to be more susceptible to mood disturbance in volleyball,[11] age was added as a fixed effect in the analysis. ~~Specifically, an LMM was performed using RPE score as dependent variables, while Edwards' ITL scores, position, and age were the fixed effects. Two other LMM were performed using dependent variables (ie, ITL Edwards' and session-RPE scores), while the fixed effects were the presession well-being (ie, sleep quality/disorders, stress level, perceived fatigue, and DOMS), position, and age. In all LMM, to account for error in repeated measures, players and sessions were considered as nested (subject in session) random effects.~~ In case of significance for the 5 position groups, post hoc pairwise comparisons were performed using the Tukey correction. Linear models with and without position and age as fixed effects were compared with each other using the Bayesian information criteria, determining the model with the lowest Bayesian information criteria score as "parsimonious."[24] Cohen *d* effect sizes were calculated to describe the practical meaningfulness of the differences in mean values.[25] The level of significance was set at 5% ($P < .05$). All data were analyzed using statistical package R (~~version 3.5.2~~)[26] with the packages "lme4"[27] and "emmeans."[28]

Results

A total of 290 individual training sessions (mean session duration = 1:36:12 [0:22:24], in h:min:s) ~~were~~ monitored within 32 team training sessions. The overall descriptive results (mean and 95% CI) about the HI (ie, sleep quality/disorders, stress level, perceived fatigue, DOMS, and the session-RPE) are reported in Table 1.

Edwards' score ($\beta = 0.006$; 95% CI, 0.001 to 0.009; SE = 0.002; *t* ratio = 2.75; $P = .006$; $d = 0.16$) significantly predicted the RPE score.

Perceived fatigue index ($\beta = 32.97$; 95% CI, 2.75 to 63.33; SE = 15.30; *t* ratio = 2.15; $P = .032$; $d = 0.13$) and age ($\beta = 5.77$; 95% CI, 0.66 to 10.89; SE = 2.59; *t* ratio = 2.22; $P = .027$; $d = 0.13$) significantly predicted session-RPE. Moreover, significant differences between positions were observed ($F = 4.13$; $P = .027$). Central blockers showed higher session-RPE compared with the liberos (estimate mean difference = 102.62; 95% CI, 5.18 to 200.20; $P = .033$; $d = 0.17$) and hitters (estimate mean difference = 86.91; 95% CI, 15.07 to 158.80; $P = .008$; $d = 0.19$). Yet, no difference was observed between the other roles (all Ps > .05).

Only age significantly predicted Edwards' score ($\beta = -4.04$; 95% CI, −5.69 to 2.38; SE = 0.83; *t* ratio = −4.81; $P < .001$; $d = -0.28$) and session-RPE ($\beta = 5.77$; 95% CI, 0.66 to 10.89; SE = 2.59; *t* ratio = 2.22; $P = .027$; $d = 0.13$). Moreover, significant differences between positions were observed ($F = 10.5036$; $P < .001$). Central blockers showed higher Edwards' scores compared with the liberos (estimate mean difference = 38.85; 95% CI, 7.41 to 70.29; $P = .007$; $d = 0.2$) and hitters (estimate mean difference = 41.84; 95% CI, 18.64 to 65.04; $P < .001$; $d = 0.29$). Moreover, liberos showed a lower score compared with the setter (estimate mean difference = 41.80; 95% CI, −75.29 to −8.30; $P = .006$; $d = -0.2$). On the contrary, no difference was observed between the other roles (all Ps > .05). An overview of LMM outputs for Edwards' and session-RPE ~~was~~ reported in Table 2, whereas the values regarding the 2 observed methods in relation to each position's roles are shown in Figure 2.

Discussion

As ITL is considered a complex psychophysiological response to both the external training load and the well-being state, the aim of this study was to assess the association between the ~~presession~~ well-being and the athletes' ITL (ie, Edwards' values and session-RPE) in elite female volleyball players. The main finding of this study was that the ~~presession~~ perceived fatigue influenced ITL only according to session-RPE but not according to the Edwards' method.

Owing to the peculiarities of volleyball, results in this study should be considered specifically for senior female volleyball. Consequently, because in this study, only perceived fatigue influenced session-RPE ITL, it may specifically contribute toward players' response to the training stimulus more than sleep quality, stress, and DOMS. However, this is partially in contrast to previous studies that reported muscle soreness on the one hand, and perceived stress, sleep quality, and fatigue on the other hand, which are associated with ITL in American football[7] and soccer,[19] respectively.

Nevertheless, in this study, well-being perception was related to the perceived (ie, session-RPE) but not to the HR-based ITL (ie, Edwards'). In association with the trivial relationship ($d = 0.16$) found between session-RPE and Edwards' scores, it may be suggested that HR-based ITL could not be fully considered as a "gold standard" in net sports, such as volleyball. In fact, aerobic metabolism is relevant in volleyball to restore the energy consumed during repeated explosive anaerobic efforts, such as attacks, blocks, and defense actions.[12,29] In this scenario, HR-based ITL, apart from perceived exertion, could be characterized by limitations when properly evaluating in short but maximal anaerobic efforts.

Similar to the mood states reported in male volleyball,[11] players' perceptions are influenced by age. In fact, in our study, this variable resulted negatively and positively correlated to Edwards' and session-RPE ITL, respectively. In particular, older players have perceived training to be harder than the younger players, despite the HR-based ITL seems to report the opposite

Table 1 Descriptive Statistics (Mean; 95% CI) of Well-Being and ITL (ie, Edwards' and Session-RPE) Parameters According to Position

	Well-being					ITL	
	Sleep quality	Stress	Fatigue	DOMS	Hooper's index	Edwards'	Session-RPE
Hitters	3.1; 3 to 3.3	3.3; 3.1 to 3.5	3.6; 3.5 to 3.8	3.8; 3.6 to 4	13.8; 13.3 to 14.3	172; 161 to 184	402; 360 to 445
Liberos	3.2; 2.8 to 3.6	3.5; 3.2 to 3.9	4; 3.7 to 4.3	4.8; 4.4 to 5.2	15.6; 14.6 to 16.5	180; 165 to 196	313; 267 to 359
Central blockers	3.4; 3.2 to 3.7	3.7; 3.4 to 3.9	4.3; 4.1 to 4.6	4.6; 4.3 to 4.8	15.9; 15.2 to 16.7	207; 193 to 221	534; 468 to 601
Opposites	3.1; 2.8 to 3.4	3.9; 3.6 to 4.2	3.9; 3.6 to 4.2	4.4; 4.1 to 4.7	15.3; 14.4 to 16.3	206; 190 to 221	463; 395 to 531
Setters	3.8; 3.6 to 4.0	3.6; 3.4 to 3.8	3.8; 3.6 to 4	3.8; 3.5 to 4.1	15.0; 14.4 to 15.5	233; 206 to 261	351; 315 to 388

Abbreviations: CI, confidence interval; DOMS, delayed onset muscle soreness; ITL, internal training load; RPE, rate of perceived exertion.

Table 2 Outcomes of LMM (β Values) Applied for Well-Being Parameters, Age, and Positions (Compared With the Central Blockers) in Relation to the 2 ITL Methods (ie, Edwards' and Session-RPE)

	Edwards'			Session-RPE		
Parameters	β	**SE**	***P* value**	β	**SE**	***P* value**
Well-being						
Sleep quality, AU	2.30	3.71	.534	0.11	11.53	.991
Stress, AU	1.57	3.67	.667	14.56	11.39	.202
Fatigue, AU	−5.01	4.89	.306	32.96	15.30	.032*
DOMS, AU	−0.49	3.28	.880	10.58	10.23	.302
Age	−4.04	0.83	<.001***	5.77	2.59	.027*
Position						
Hitters	−41.83	8.27	<.001***	−86.91	25.68	<.001***
Liberos	−38.84	11.23	<.001***	−102.67	34.86	.003**
Opposites	−14.99	9.05	.099	−35.22	28.04	.21
Setters	2.94	10.89	.786	−89.32	33.75	.008**

Abbreviations: DOMS, delayed onset muscle soreness; ITL, internal training load; LMM, linear mixed-effects models; RPE, rate of perceived exertion.

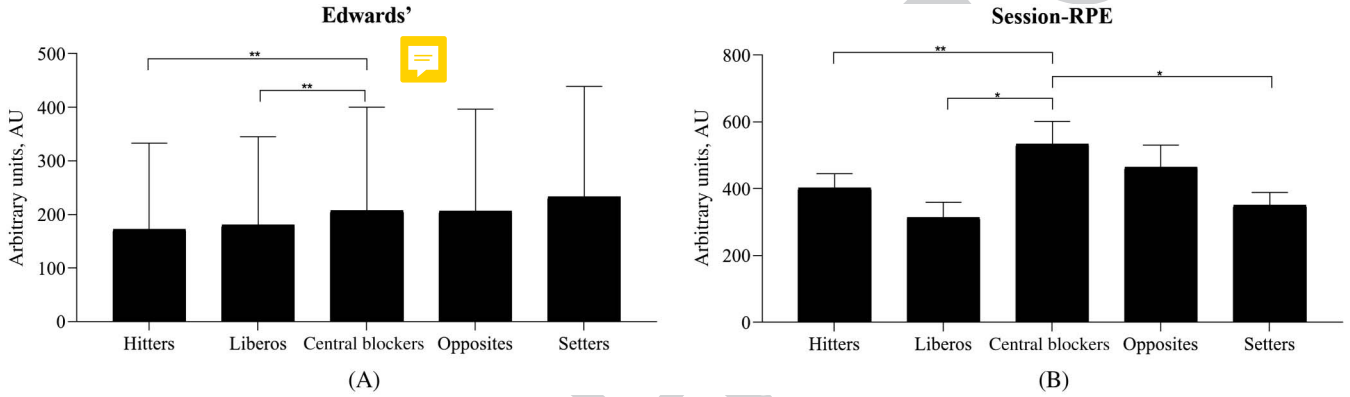

Figure 2 — Differences regarding the 2 observed methods (Edwards' and session-RPE) in relation to each position roles (*$P \le .01$; **$P \le .001$). RPE indicates rate of perceived exertion.

scenario. In fact, for the observed training sessions, in which real competition was simulated, it could be speculated that the lower mean HR intensity reported by the older players is associated with a lower ability in coping with the intensity level required by the coaches, thus confirming the finding of a previous study for which high-intensity and short-duration exertion may not be directly related to the enhancement of the Edwards' ITLs.[30] Consequently, in this training scenario, coaches should take age into account when monitoring both objective and subjective ITLs.

According to the specialized fitness and morphological qualities associated with the different playing positions,[22] effects for ITL (ie, Edwards' values and session-RPE) related to different positions were also expected. The results of this study reported that central blockers experienced both a higher Edwards' ITL than hitters and liberos, and a higher session-RPE level than hitters, liberos, and setters. These differences may be due to the higher involvement of the central blockers during the defensive phase. In fact, according to Araújo et al,[31] male central blockers are involved in almost all blocking systems (ie, man-to-man and zone blocking) with relevant implication for the process of training. Considering blocking as a fundamental skill, with more blocks and fewer blocking errors related to success in elite-level competition,[13] the massive involvement of the central blockers during the training sessions could explain their higher ITL experienced in this study.

However, this study can also been characterized by some limitations. According to the coaches perspective, only the collective (ie, full team and 6v6) training sessions were monitored because they were considered as the most valid representation of the performance during the in-season period. Nevertheless, the other sessions were rare and with low training loads because they were more didactic than conditioning, and focused only on technical and/or tactical skills specific for the play roles, which should not have caused any significant effect on the ITL of the analyzed sessions. In addition, despite that strength and conditioning sessions were regularly performed during the season, ITL was not assessed in this study. Therefore, future studies on ITL should define the validity of the experimental approach by providing mixed-effects models able to consider external load (eg, number of jumps), other types of training (ie, technical and strength and conditioning), and training load effects occurring the day after the well-being status recording.

Practical Applications

Coaches should be aware of the importance of well-being status on the perceived exertion in effectively monitoring training in female volleyball players. In fact, presession perceived fatigue

should be constantly monitored, despite no relation existing with the Edwards' ITL method. Assessing it before the training session could be important to determine if players will be able to effectively perform the training session and benefit from planned training stimuli.

Although it is complicated to propose different intensities for each position during the full squad training (ie, tactical training), coaches should be aware that central blockers experience higher loads than the other players. Therefore, coaches could adopt different substitution strategies during games and training sessions to manage intensity for the central blockers. In addition, physical coaches could also manage loads during strength and conditioning training to better prepare central blockers to cope with the game demands. Practically, they could project repeated-effort training sessions incorporating block jumps, spike jumps, fake spike jumps, and multidirectional court movements. High-intensity exercises, followed by brief rest periods or low-intensity activity, could develop glycolytic metabolic and creatine phosphate pathways for women volleyball players.[32]

Conclusions

This study showed that the ~~presession~~ well-being perception can affect the ITL in senior female volleyball. However, this relationship was verified only between the ~~presession~~ perceived fatigue and the perceived ITL (ie, session-RPE). In addition, older players have been shown to perceive training harder than the younger players, with their HR responses lower than younger counterparts, even suggesting a lower ability in coping with the intensity requested by coaches. Finally, differences in both objective (ie, Edwards' HR method) and subjective (ie, session-RPE) ITL were reported for players related to specific tactical roles, highlighting that central blockers experienced higher ITL than hitters, liberos, and setters.

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Q19 Q20 Q21

Queries

Q1. Please note that titles should generally not be full sentences. Please consider an edit to your title to avoid the full sentence. Also abbreviations are not preferred in title as per style.

Q2. Please check if the edits to the sentence "Twelve female elite ..." are correct and convey the intended meaning.

Q3. Please ensure author information is listed correctly here and within the byline.

Q4. Please revise the phrase "resulted highly satisfactory in monitoring" in the sentence "However, regardless of ..." for more clarity.

Q5. Please revise the phrase "resulted related to perceived presession" for more clarity.

Q6. As per journal style, "mean ± SD" should be represented as "mean (SD)." Hence, the values are changed accordingly. Please check and confirm.

Q7. Please check if the edits to the sentence "The inclusion criteria for ..." are correct and convey the intended meaning.

Q8. Please check if "According to the literature ..." can be changed to "According to Luco et al... ."

Q9. Please note that the meaning of the phrase "performed using as dependent variables" is not clear in the sentence "Two other LMM ... ." Please check and revise if necessary.

Q10. Please provide manufacturer name and location (city, state [if USA], and country) details for “lme4” and “emmeans.”

Q11. Please provide heading for first column in Table 1.

Q12. Please check if the edits to the sentence "In this scenario ..." are correct and convey the intended meaning.

Q13. Please provide significance for *,**, and *** in Table 2.

Q14. Please check if the edits to the sentence "Consequently, in this training ..." are correct and convey the intended meaning.

Q15. Please check if the edits to the sentence "According to the coaches ..." are correct and convey the intended meaning.

Q16. Please note that meaning of the sentence "Nevertheless, the other ..." is not clear. Please check and rephrase for more clarity.

Q17. Please provide volume number and issue number for Ref. 6.

Q18. Please provide issue number for Refs. 17, 19, and 20.

Q19. Please provide the publisher location and name for Ref. 26.

Q20. Please provide the page range for Ref. 27.

Q21. Please provide URL link and accessed date (day, month, and year) for Ref. 28.