Paper

Jump performance and salivary secretory immunoglobulin A in female volleyballers

Ryota SONE[*1, *2], Ken NEMOTO[*3], Honoka GOJI[*4] and Kenji OHISHI[*3]

*1 Faculty of International Agriculture and Food Studies, Tokyo University of Agriculture

*2 Department of Sport Research, Japan Institute of Sports Sciences

*3 Faculty of Sport Science, Nippon Sport Science University

7-1 Fukasawa, Setagaya-ku, Tokyo 158-8508 Japan

oishi@nittai.ac.jp

*4 Graduate School of Health and Sport Science, Nippon Sport Science University

Received February 17, 2022 ; Accepted June 20, 2022

High-intensity exercise risks lowering salivary secretory immunoglobulin A (s-SIgA), and a lower s-SIgA level is associated with upper respiratory tract infections. Volleyball training camps have reported s-SIgA level reduction. Nonetheless, the relationship between jump performance and s-SIgA remains unclear. This observational study aimed to investigate the effect of a single volleyball game on the s-SIgA response and the relationship between in-game jump performance and changes in s-SIgA secretion. Thirteen elite collegiate female volleyball players (mean age, 20.6 ± 1.4 years) participated. Pre- and post-match saliva samples and questionnaires were collected; s-SIgA concentrations were quantified from saliva samples, and s-SIgA secretion rates were calculated. Jump data were measured using the jump load management platform "VERT Coach". Jump performance was assessed by the number of jumps, total work, and work per time. Pre- and post-match s-SIgA secretion rates did not significantly change (44.7 ± 17.4 and 47.1 ± 21.7 µg/min, respectively); however, s-SIgA secretion rates decreased in 8 of 13 players. Changes in s-SIgA secretion rates did not significantly correlate with any jump performance. Our results suggest that a single volleyball game did not affect s-SIgA response and that in-game jump performance in female volleyball players was not associated with s-SIgA response.

Key words : game performance, upper respiratory tract infections, psychological stress

Human Performance Measurement Vol. 19, 1-8 (2022)

1. Introduction

Athletes intensify their training to ensure high-level performance during an official game, and pre-match preparation often leads to increased levels of physical and psychological stress in an athlete (Hiraoka et al., 2019). This may reduce immune function and increase the risk of upper respiratory tract infection (URTI) (Fahlman and Engels, 2005; Hiraoka et al., 2019). A reduction in salivary secretory immunoglobulin A (s-SIgA), which is associated with a high URTI risk (Fahlman and Engels, 2005; Gleeson et al., 2012; Neville et al., 2008), has been reported to remain unchanged during a simulated game and to decrease during an official match (Freitas et al., 2016). Mucosal epithelial cells such as those in the oropharyngeal and nasal mucosa secrete s-SIgA, which plays an important role in specific URTI-related immunity. In addition to chronically low s-SIgA levels (Fahlman and Engels, 2005; Gleeson et al., 2012), transient declines have also been associated with an increased URTI risk (Neville et al., 2008). Several studies have investigated the s-SIgA response in high-intensity intermittent endurance sports matches, including soccer (Freitas et al., 2016), basketball (Moreira et al., 2013a), and Australian rules football (Coad et al., 2015). The s-SIgA response to a match may be influenced by the type of sport being played, the number of matches, or whether an official match was being played, as results have been reported to vary (Coad et al., 2015; Freitas et al., 2016; Moreira et al., 2013a). The s-SIgA has also been reported to respond to psychological stress (Bosch et al., 2001). Official matches can be a factor in psychological stress. Previous study has shown that s-SIgA responses differ between simulated and official matches despite the same match time (Freitas et al., 2016). Thus, when assessing s-SIgA response before and after a match, psychological status should also be investigated.

In volleyball, the characteristic exercise style involves frequent repeated high jumps and short rest periods. Various high-intensity sports induce a decline in immune function (Fahlman and Engels, 2005; Nieman, 1994); however, the relationship between repeated high jumping and immune function is unclear. A previous study that observed the duration of a pre-season volleyball training camp reported a decrease in s-SIgA secretion rates after the training camp, but any association with jumps was not investigated (Sone et al., 2021). Moreover, few studies have investigated players' immune function following a volleyball match.

In volleyball, game-related performance factors have been actively analysed (Peña and Casals, 2016). Previous studies have examined the relationship between the global positioning system (GPS)-based game analysis and s-SIgA in rugby union games (Lindsay et al., 2015a; Lindsay et al., 2015b); however, the relationship of volleyball-specific performance analysis results with the changes in s-SIgA secretion rates remains unclear. Therefore, the effect of jump quality (height) and quantity (frequency) during a volleyball match on changes in s-SIgA remains to be determined. Using results from this study, it may be possible to predict a player's health status (immune function) from the results of jumps in a performance analysis not only during a game but also during training.

Based on this background, we hypothesised that a volleyball match involving frequent high jumps influences s-SIgA secretion rates and concentrations and that jump performance relates to pre- and post-match changes in s-SIgA levels. The association between the jump performance of volleyball players and s-SIgA has not been investigated. This study aimed to investigate the effect of an official collegiate volleyball match on the psychophysical status of players and the relationship between jump performance and s-SIgA levels.

2. Methods

2. 1. Participants

Nineteen female collegiate volleyball players from an elite university volleyball team in Japan participated in this observational study. This team belongs to the Kanto University Volleyball Federation Division 1 and was the top 8 in the All Japan Inter-College Championships. All participants were non-smokers, with no disease or injury, and were not taking any medication. This study was reviewed and approved by the Ethics Committee of authors' affiliated institution. All procedures were performed in accordance with the ethical guidelines of the Declaration of Helsinki. All potential risks and procedures of the study were explained to the participants, who provided informed consent prior to participation. Data from 6 athletes who did not participate in the investigated match were excluded. Thus, data from 13 athletes were retained for statistical analysis.

2. 2. Study design

The analysed match was an alternative to the official autumn league, which had been cancelled due to the COVID-19 pandemic. All games were held without spectators. The team players and support staff recognised this alternative match as an official match, which was the first match of 11 matches played in the autumn league between October 3 and November 22, and the target match of this study. On the day of the match, all players arrived in the waiting room at 09:00 a.m., more than 2 hours after breakfast. Participants were instructed to refrain from alcohol and caffeine consumption on the day prior to the day of the match. Two measurement points were set for before (between 9:00 and 9:30 a.m.) and after (within 15 min from the end of the match at 0:30 p.m.) the match. Stimulated saliva collection, filling of a questionnaire, and the completion of the Japanese version of the Profile of Mood States Second Edition (POMS 2®) questionnaire (Heuchert and McNair, 2012) were conducted at the two measurement points (pre- and post-match). The match was a 5-set match, and the study team won the match, with a set count of 3-0.

2. 3. Salivary assay

Saliva samples were collected, as previously described (Akimoto et al., 2003). Stimulated saliva, secreted through the action of chewing 60 times for 60 s, was collected using a sterile cotton swab (Salivette; Sarstedt Inc., Numbrecht, Germany). The saliva was centrifuged at 3,000 rpm for 15 min to measure the saliva flow rate (volume). Following the measurement of the sample volume, all saliva samples were frozen at -40 °C and stored until the end of the study period. The s-SIgA concentrations were measured using an enzyme-linked immunosorbent assay (ELISA), as previously reported (Akimoto et al., 2003). The s-SIgA secretion rate was calculated as follows: s-SIgA secretion rate (μg/min) = saliva flow rate (mL/min) × s-SIgA concentration (μg/mL). s-SIgA concentrations and saliva flow rates have been reported to change in the morning, even at rest; nevertheless, secretion rates do not change (Leicht et al., 2018).

Subjective evaluation of stress

Two questionnaires were used to subjectively assess stress. First, players responded to a questionnaire regarding their subjective feelings, including questions about the total condition, physical stress, psychological stress, tension-anxiety prior to the match, upper body incompatibility, and lower body incompatibility, using a visual analogue scale (VAS). Participants marked how they felt at each measurement point on a 100-mm line along a good (none) and bad (full) VAS, with low values representing poor psychophysiological conditions. A second questionnaire, the POMS 2® (ON, Canada), was used to determine the mood states of the volleyball players. This short version comprises 35 self-report items using a 5-point Likert scale (Heuchert and McNair, 2012). The POMS 2® measures the following seven different mood dimensions: anger-hostility (AH), confusion-bewilderment (CB), depression-dejection (DD), fatigue-inertia (FI), tension-anxiety (TA), vigour-activity (VA), and friendliness (F). The total mood disturbance (TMD) was calculated using these 6 subscale scores without F. Low AH, CB, DD, FI, TA, and TMD scores indicated good status in each domain, whereas higher VA and F scores indicated better conditions.

2. 4. Evaluation of jump performance

Participants' jumping height and frequency during the match were measured using a wearable device (VERT Coach; S&C Corp., Kyoto, Japan) with a built-in 3-axis accelerometer, 3-axis gyroscope, and 3-axis magnetometer. Total work (Nm) was calculated from the jump frequency, jumping height, and weight of each participant. Values were calculated by dividing the jump frequency by the total work and were recorded as work per jump (work/time).

2. 5. Statistical analyses

A Shapiro–Wilk test was used to evaluate the normality of the distributions. Data are expressed as mean ± SD or median (interquartile range). Differences between the pre- and post-match tests were assessed using paired t- or Wilcoxon signed-rank tests, as appropriate. This study targeted one team; therefore, the sample size was small, and the effect size (r) was hence calculated. Spearman's rank correlation test (r_s) was used to express linear correlations between changes in s-SIgA secretion rates and jump performance (frequency of jump, total work, and work/time). Statistical significance was set *a priori at* $P < 0.05$ for all analyses. All statistical analyses were performed using IBM SPSS Statistics for Macintosh, Version 25.0 (IBM Corp., Armonk, NY, USA) software.

3. Results

Table 1 shows the changes in participants' variables before and after the match and jump performance during the match. The results of the two questionnaires, which were subjective indicators of stress, indicated no significant changes except for TA, F scores in the POMS 2® before and after the match. Both TA and F scores significantly decreased after the match. Saliva flow rates, s-SIgA concentrations, and s-SIgA secretion rates did not change from the start to the end of the match.

Figure 1 shows the changes in s-SIgA secretion rates before and after the volleyball match in each player. Five of 13 players showed increased s-SIgA secretion rates after the match. However, 8 players (approximately 60% of the team) had decreased post-match s-SIgA secretion rates.

Table 1. Characteristics of volleyball players before and after the match.

Variable (*n* = 13)		**Pre-match**	**Post-match**	***P*-value**	**Effect size (*r*)**
Profile	Age (years)	20.6 ± 1.4	–	–	–
	Height (cm)	170.0 ± 6.2	–	–	–
	Body weight (kg)	62.7 ± 6.3	–	–	–
Visual analogue scale	Total condition (mm)	75.1 ± 14.6	73.5 ± 16.3	0.593	0.16
	Physical stress (mm)	69.5 ± 14.5	58.2 ± 20.7	0.136	0.42
	Psychological stress (mm)	70.1 ± 18.9	57.9 ± 21.9	0.141	0.41
	Tension-anxiety for match (mm)	52.4 ± 20.7	68.0 ± 26.8	0.122	0.43
	Upper body-incompatibility (mm)	62.9 ± 25.8	65.1 ± 25.9	0.715	0.11
	Lower body-incompatibility (mm)	63.7 ± 28.6	64.2 ± 25.8	0.928	0.03
POMS 2	Anger-hostility	2.00 [0.00-5.00]	0.00 [0.00-1.50]	0.235	-0.33
	Confusion-bewilderment	4.00 [1.50-5.00]	2.00 [0.50-5.50]	0.124	-0.43
	Depression-dejection	2.00 [0.00-5.00]	2.00 [0.00-6.50]	0.687	-0.11
	Fatigue-inertia	2.00 [0.00-4.50]	4.00 [1.00-9.00]	0.258	-0.31
	Tension-anxiety	8.00 [4.00-10.50]	3.00 [1.00-5.00]	0.022	-0.63
	Vigor-activity	13.62 ± 3.89	11.08 ± 5.20	0.086	0.48
	Friendliness	14.31 ± 2.56	12.46 ± 2.40	0.038	0.56
	Total mood disturbance	1.00 [-6.00-13.00]	-3.00 [-6.50-16.00]	0.504	-0.19
Salivary components	Saliva flow rate (mL/min)	1.77 ± 0.57	1.87 ± 0.56	0.425	0.23
	s-SIgA concentration (μg/mL)	26.5 ± 10.2	25.8 ± 10.1	0.769	0.09
	s-SIgA secretion rates (μg/min)	44.7 ± 17.4	47.1 ± 21.7	0.570	0.17
Jump performance	Frequency	–	48 ± 39	–	–
	Total work (Nm)	–	12827 ± 11085	–	–
	Work/time (total work/frequency)	–	224 ± 89	–	–

Data are shown as means ± SD or as median [interquartile range].

Abbreviations: POMS 2 = Profile of Mood States Second Edition; s-SIgA = salivary secretory immunoglobulin A; SD = standard deviation.

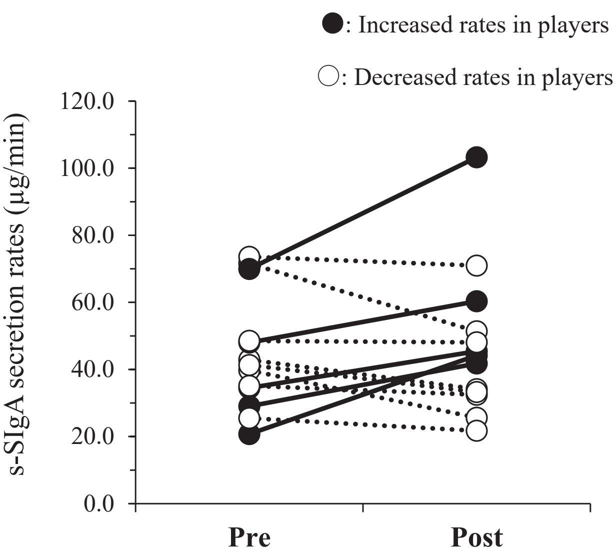

Figure 1. Changes in s-SIgA secretion rates before and after the alternative match. s-SIgA: salivary secretory immunoglobulin A.

Figure 2 shows the univariate associations between changes in s-SIgA secretion rates and various jump parameters in the match, including frequency of jumps, total work, and work/time. Changes in s-SIgA secretion rates did not correlate significantly with any of the indicators of frequency (r_s = -0.104, P = 0.734; Figure 2A), total work (r_s = -0.093, P = 0.762; Figure 2B), and work/time (r_s = 0.104, P = 0.734; Figure 2C).

4. Discussion

The relationship between jump performance and s-SIgA remains unclear. This study investigated the effects of a volleyball match on the relationship between jump analysis and changes in s-SIgA secretion rates. Our findings showed that, while there was no significant change in s-SIgA secretion rates after one volleyball match, the s-SIgA secretion rates decreased in 8 out of 13 players. No significant correlations between any qualitative (height) or quantitative (frequency) jump performance parameter during the match and changes in s-SIgA secretion rates after the match were identified. However, the subjective

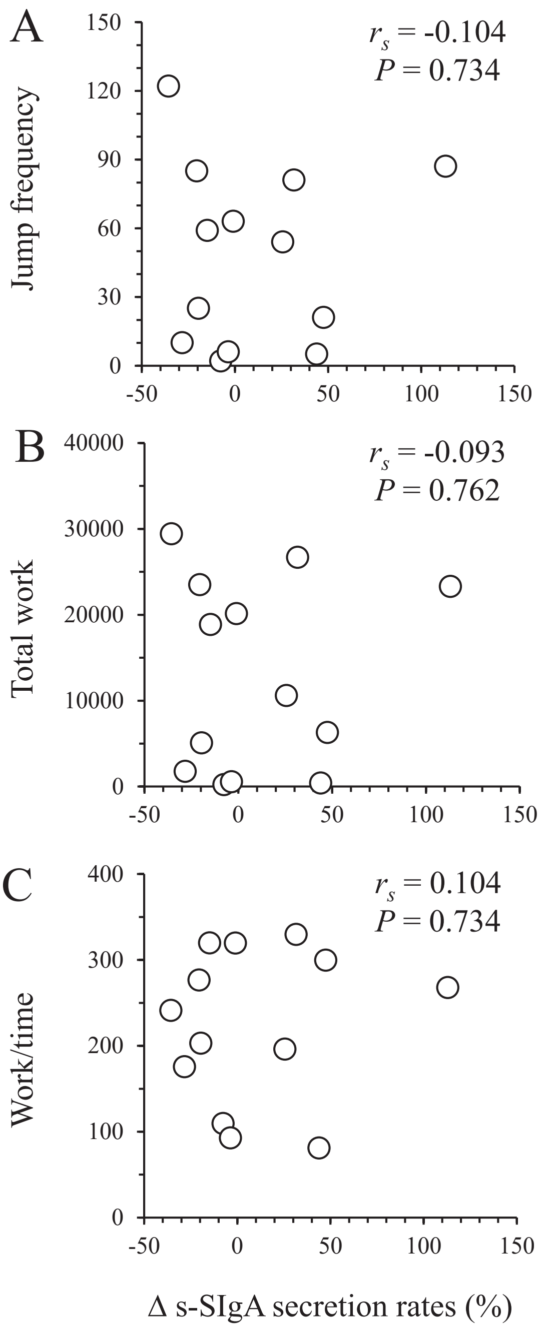

Figure 2. Univariate correlations of the changes in s-SIgA secretion rates with the frequency of jump (A), total work (B), and work/time (C). s-SIgA: salivary secretory immunoglobulin A

TA significantly decreased after the match. These results suggest that, in a volleyball match where tension levels are likely to be high, such as an official match, the s-SIgA secretion rates may not be influenced by just one game and that jump performance may not be related to changes in s-SIgA secretion rates.

Previous studies have reported s-SIgA responses in various sports where vigorous exercise occurs intermittently (Coad et al., 2015; Freitas et al., 2016; Koch et al., 2007; Moreira et al., 2009; Moreira et al., 2013a; Moreira et al., 2013b). Few studies have examined the s-SIgA response in volleyball games. Therefore, we investigated the influence of a university league volleyball match on s-SIgA secretion rates. In team sports, such as basketball (Moreira et al., 2013a), rugby (Koch et al., 2007), and soccer (Moreira et al., 2009), s-SIgA responses before and after the games have been reported to be unchanged in one match. Additionally, a previous study involving male volleyball players showed that match importance affected the extent of decline in s-SIgA; however, there was no change before and after the match (Moreira et al., 2013b). The s-SIgA responses in our study were in accordance with those in previous studies examining the effects of a single match on s-SIgA (Koch et al., 2007; Moreira et al., 2009; Moreira et al., 2013a; Moreira et al., 2013b). In this study and in a previous study (Moreira et al., 2013b), the volleyball match ended with a set count of 3-0. Therefore, the effect of long games involving a full number of sets on s-SIgA responses remains unknown and should be investigated in the future.

Psychological stress also affects s-SIgA. Previous studies have reported that chronic psychological stress induces low s-SIgA (Jemmott et al., 1983) and that the duration of psychological stress is associated with reduced s-SIgA concentrations (Deinzer et al., 2000). Additionally, s-SIgA has been shown to decrease during the build-up to a championship match (Moreira et al., 2013b) and does not change in the simulation match but decreases in the official match (Freitas et al., 2016). The findings of this study indicated that subjective TA improved after the match when assessed using the POMS 2®. Therefore, we considered that psychological stress was increasing during the build-up to this match. A previous study showed that athletes had lower s-SIgA levels than sedentary people (Li et al., 2012). It is possible that s-SIgA may have been lower than usual because of the high psychological stress due to continuous pre-match training; however, baseline s-SIgA levels were not measured.

Of note, 8 out of 13 players, corresponding to 60% of the players in the team, showed a decrease in s-SIgA. s-SIgA during one game of rugby has been reported to not change (Koch et al., 2007); however, s-SIgA has also been shown to decrease with repeated games in Australian rules football, which has similar exercise characteristics to rugby (contact sport) (Coad et al., 2015). The volleyball game in this study was targeted at the first of 11 league games; therefore, this may explain why no change in s-SIgA was observed. s-SIgA does not change in a single volleyball game (Moreira et al., 2013b) or during a single volleyball practice (Bruzda-Zwiech et al., 2017). If the study had targeted a later match in the league series, a different response may have been observed. Future studies are required to investigate s-SIgA responses continuously throughout multiple volleyball games. In other words, continuous s-SIgA monitoring throughout the season would be beneficial. Monitoring s-SIgA to reduce the URTI incidence can lead to more efficient training strategies for volleyball coaches and athletes.

To evaluate the effect of jumping, which is a frequently repeated exercise in volleyball, the relationship between jumping and s-SIgA was examined using a jump analysis device. No significant correlation was found between jump performance during the match and changes in s-SIgA. Since s-SIgA did not change before and after the match, it is possible that the relationship with jump performance was masked. The small number of sets (n = 3) may have affected the jump frequency of the participating players. Some players had a very small number of jumps because data from only one set were used in this study. Therefore, it is necessary to consider position characteristics, the number of sets, and the number of individual jumps when confirming the relationship between jump performance and s-SIgA in volleyball players.

This study has several limitations. First, differences in the playing position were not examined. The roles required for volleyball differ depending on each playing position, and the load applied to the players also differs. For example, the setter performs a larger number of jumps compared to players in other positions (Skazalski et al., 2018), but the setter's jump load is small (García-de-Alcaraz et al., 2020). Second, the play time on the court was not investigated in this match. A positive correlation between maximal oxygen consumption and changes in s-SIgA levels has been reported (Engels et al., 2018). This suggests that there may be a relationship between endurance performance and s-SIgA. It is necessary to consider the relationship between s-SIgA and other volleyball-specific performances, including game-related performance factors, in a game analysis. Despite these limitations, it was important to obtain jump data and investigate the relationship with s-SIgA in a single match that corresponded to an actual competition. While there have been several reports on the relationship between URTI and s-SIgA, many issues concerning the underlying mechanisms remain unclear (Turner et al., 2021), and these require further investigation in future studies.

5. Conclusion

In conclusion, a single volleyball match showed no significant change in s-SIgA responses; nevertheless, the s-SIgA level decreased in 8 out of 13 players. No association between in-game jump performance and changes in s-SIgA was observed in this study, suggesting that s-SIgA monitoring should be undertaken in consecutive games rather than in a single game.

Data availability statement

The datasets used and/or analysed in this study are available from the corresponding author on reasonable request.

References

Akimoto, T., Kumai, Y., Akama, T., Hayashi, E., Murakami, H., Soma, R., Kuno, S., and Kono, I. (2003). Effects of 12 months of exercise training on salivary secretory IgA levels in elderly subjects. British Journal of Sports Medicine, 37(1), 76–79. https://doi.org/10.1136/bjsm.37.1.76.

Bosch, J. A., de Geus, E. J., Kelder, A., Veerman, E. C., Hoogstraten, J., and Amerongen, A. V. (2001). Differential effects of active versus passive coping on secretory immunity. Psychophysiology, 38(5), 836–846.

Bruzda-Zwiech, A., Konieczka, M., Hilt, A., Daszkowska, M., Grzegorczyk, J., and Szczepańska, J. (2017). Salivary cortisol, alpha-amylase and immunoglobulin a responses to a morning session of basketball or volleyball training in boys aged 14-18 years. Journal of Biological Regulators and Homeostatic Agents, 31(1), 105–110.

Coad, S., Gray, B., Wehbe, G., and McLellan, C. (2015). Physical demands and salivary immunoglobulin A responses of elite Australian rules football athletes to match play. International Journal of Sports Physiology and Performance, 10(5), 613–617. https://doi.org/10.1123/ijspp.2014-0493.

Deinzer, R., Kleineidam, C., Stiller-Winkler, R., Idel, H., and Bachg, D. (2000). Prolonged reduction of salivary immunoglobulin A (sIgA) after a major academic exam. International Journal of Psychophysiology, 37(3), 219–232. https://doi.org/10.1016/s0167-8760(99)00112-9.

Engels, H. J., Kendall, B. J., Fahlman, M. M., Gothe, N. P., and Bourbeau, K. C. (2018). Salivary immunoglobulin A in healthy adolescent females: effects of maximal exercise, physical activity, body composition and diet. The Journal of Sports Medicine and Physical Fitness, 58(7-8), 1096–1101. https://doi.org/10.23736/S0022-4707.17.07845-8.

Fahlman, M. M., and Engels, H. J. (2005). Mucosal IgA and URTI in American college football players: a year longitudinal study. Medicine and Science in Sports and Exercise, 37(3), 374–380. https://doi.org/10.1249/01.mss.0000155432.67020.88.

Freitas, C. G., Aoki, M. S., Arruda, A. F., Franciscon, C., and Moreira, A. (2016). Monitoring salivary immunoglobulin A responses to official and simulated matches in elite young soccer players. Journal of Human Kinetics, 53, 107–115. https://doi.org/10.1515/hukin-2016-0015.

García-de-Alcaraz, A., Ramírez-Campillo, R., Rivera-Rodríguez, M., and Romero-Moraleda, B. (2020). Analysis of jump load during a volleyball season in terms of player role. Journal of Science and Medicine in Sport, 23(10), 973–978. https://doi.org/10.1016/j.jsams.2020.03.002.

Gleeson, M., Bishop, N., Oliveira, M., McCauley, T., Tauler, P., and Muhamad, A. S. (2012). Respiratory infection risk in athletes: Association with antigen-stimulated IL-10 production and salivary IgA secretion. Scandinavian Journal of Medicine and Science in Sports, 22(3), 410–417. https://doi.org/10.1111/j.1600-0838.2010.01272.x.

Heuchert, J.P., and McNair, D.M. (2012). Profile of mood states (2nd ed.). Multi-Health Systems (MHS).

Hiraoka, H., Hanaoka, Y., Jesmin, S., Kimura, F., Matsuish, Y., Shimizu, K., and Watanabe, K. (2019). Variation of salivary IgA during weight loss period before a competition among university judo players. Journal of Clinical Medicine Research, 11(12), 798–806. https://doi.org/10.14740/jocmr3998.

Jemmott, J. B., 3rd, Borysenko, J. Z., Borysenko, M., McClelland, D. C., Chapman, R., Meyer, D., and Benson, H. (1983). Academic stress, power motivation, and decrease in secretion rate of salivary secretory immunoglobulin A. Lancet (London, England), 1(8339), 1400–1402. https://doi.org/10.1016/s0140-6736(83)92354-1.

Koch, A. J., Wherry, A. D., Petersen, M. C., Johnson, J. C., Stuart, M. K., and Sexton, W. L. (2007). Salivary immunoglobulin A response to a collegiate rugby game. Journal of Strength and Conditioning Research, 21(1), 86–90. https://doi.org/10.1519/00124278-200702000-00016.

Leicht, C. A., Goosey-Tolfrey, V. L., and Bishop, N. C. (2018). Exercise intensity and its impact on relationships between salivary immunoglobulin A, saliva flow rate and plasma cortisol concentration. European Journal of Applied Physiology, *118*(6), 1179–1187. https://doi.org/10.1007/s00421-018-3847-6.

Li, T. L., Lin, H. C., Ko, M. H., Chang, C. K., and Fang, S. H. (2012). Effects of prolonged intensive training on the resting levels of salivary immunoglobulin A and cortisol in adolescent volleyball players. The Journal of Sports Medicine and Physical Fitness, 52(5), 569–573.

Lindsay, A., Lewis, J., Scarrott, C., Draper, N., and Gieseg, S. P. (2015a). Changes in acute biochemical markers of inflammatory and structural stress in rugby union. Journal of Sports Sciences, 33(9), 882–891. https://doi.org/10.1080/02640414.2014.971047.

Lindsay, A., Lewis, J. G., Scarrott, C., Gill, N., Gieseg, S. P., and Draper, N. (2015b). Assessing the effectiveness of selected biomarkers in the acute and cumulative physiological stress response in professional rugby union through non-invasive assessment. International Journal of Sports Medicine, 36(6), 446–454. https://doi.org/10.1055/s-0034-1398528.

Moreira, A., Arsati, F., Cury, P. R., Franciscon, C., de Oliveira, P. R., and de Araújo, V. C. (2009). Salivary immunoglobulin a response to a match in top-level Brazilian soccer players. Journal of Strength and Conditioning Research, 23(7), 1968–1973.

Moreira, A., Bacurau, R. F., Napimoga, M. H., Arruda, A. F., Freitas, C. G., Drago, G., and Aoki, M. S. (2013a). Salivary IL-21 and IgA responses to a competitive match in elite basketball players. Biology of Sport, 30(4), 243–247. https://doi.org/10.5604/20831862.1077548.

Moreira, A., Freitas, C. G., Nakamura, F. Y., Drago, G., Drago, M., and Aoki, M. S. (2013b). Effect of match importance on salivary cortisol and immunoglobulin A responses in elite young volleyball players. Journal of Strength and Conditioning Research, 27(1), 202–207. https://doi.org/10.1519/JSC.0b013e31825183d9.

Neville, V., Gleeson, M., and Folland, J. P. (2008). Salivary IgA as a risk factor for upper respiratory infections in elite professional athletes. Medicine and Science in Sports and Exercise, 40(7), 1228–1236. https://doi.org/10.1249/MSS.0b013e31816be9c3.

Nieman D. C. (1994). Exercise, infection, and immunity. International Journal of Sports Medicine, 15 Suppl 3, S131–S141. https://doi.org/10.1055/s-2007-1021128.

Peña, J., and Casals, M. (2016). Game-related performance factors in four European men's professional volleyball championships. Journal of Human Kinetics, 53, 223–230. https://doi.org/10.1515/hukin-2016-0025.

Skazalski, C., Whiteley, R., and Bahr, R. (2018). High jump demands in professional volleyball-large variability exists between players and player positions. Scandinavian Journal of Medicine and Science in Sports, 28(11), 2293–2298. https://doi.org/10.1111/sms.13255.

Sone, R., Yamamoto, K., and Ohishi, K. (2021). Effect of pre-season training camp on oral immune functions in elite collegiate volleyball players. The Journal of Physical Fitness and Sports Medicine, 10(1), 39–44.

Turner, S.E.G., Loosemore, M., Shah, A., Kelleher, P., and Hull, J.H. (2021). Salivary IgA as a potential biomarker in the evaluation of respiratory tract infection risk in athletes. The Journal of Allergy and Clinical Immunology: In Practice, 9(1), 151–159. https://doi.org/10.1016/j.jaip.2020.07.049.