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SEASON JUMP PERFORMANCE AND WELLNESS VARIABLES IN TURKISH NATIONAL YOUTH WRESTLERS

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ABSTRACT
Purpose. The aim of this study was 2-fold: (1) to analyse the variations of countermovement jump (CMJ) performance over the different periods of the season (early-, mid-, and end-season) and (2) to analyse the correlations between CMJ performance and wellness variables over season periods.
Methods. Overall, 10 elite young male freestyle wrestlers (aged 16.0 ± 0.7 years) participated in this study during the 32 weeks of the season. Neuromuscular performance was analysed via a CMJ protocol and well-being variables were monitored by using the Hooper index questionnaire. Repeated measures analysis of variance with eventual Bonferroni post-hoc test was applied to investigate the differences between season periods within weeks.
Results. There were no significant changes of neuromuscular performance throughout the season, which suggests the absence of neuromuscular fatigue. No relationships were found between CMJ performance and any single well-being variable. In turn, a small association was observed between weekly Hooper index and neuromuscular status early in the season (correlation coefficient: 0.20, p = 0.044).
Conclusions. Using the sum of all well-being variables instead of the single variables may be better to track possible neuromuscular status variations in wrestling athletes, particularly early in the season.
Key words: athletic performance, biomonitoring, fatigue, physical fitness

Introduction

Wrestling is an intermittent high-intensity individual sport with bouts of high-intensity actions (e.g., offensive and defensive manoeuvres) interspersed with low-intensity activities [1]. This is a highly demanding sport that requires high levels of aerobic capacity, aerobic power, anaerobic power, strength (isometric, dynamic, and endurance), and power to reach a good performance in both Greco-Roman style and freestyle wrestling [2]. Given the technical characteristics of wrestling, strength and power are required for both upper and lower body limbs; the lower limbs are more associated with power actions [1, 3]. Wrestling com-

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petitions are comprised of more than one match, with 2 periods of 3 minutes each, and a 30-second break in-between, on a single day or more days, which is highly taxing for wrestlers, thus resulting in accumulated fatigue [4, 5].

For assessing lower limb neuromuscular power performance in wrestling athletes, the most commonly used protocol is the countermovement jump (CMJ) test; the jump height values range from approximately 45 up to 60 cm for senior athletes and from 30 to 60 cm for junior athletes [2]. As mentioned earlier, a great level of leg power performance is required to succeed in wrestling [1, 4]. In detail, a study conducted in 107 elite Greco-Roman and freestyle athletes (17–20 years old) revealed that freestyle wrestlers seemed to have greater jump performance than their Greco-Roman peers [6]. Although the meaning of this difference between wrestling styles is not so straightforward, it is worth noticing that freestyle athletes may present greater jump performance, as in freestyle wrestling the athletes are allowed to use the lower limbs for the overall techniques. In turn, in Greco-Roman style, the athletes are limited to involving the upper body for all techniques [2, 7].

Furthermore, as wrestling training and competition are highly demanding, it is imperative to ensure a continuous monitoring of wrestlers' fatigue status. In order to monitor athletes' fatigue status, the assessment of vertical jump performance and well-being questionnaires are commonly used in many sports [8–10]. In fact, one of the most applied tests to evaluate possible training and competition fatigue-related effects on neuromuscular performance is the CMJ test [11]. This exercise is particularly important because it combines concentric/eccentric contraction and elastic energy storage/release abilities [12]. The use of CMJ protocols to assess neuromuscular fatigue enables to analyse the changes in jump height, flight time, peak power, and peak force, depending on the testing device [13]. There are different valid, reliable, and affordable instruments to evaluate the neuromuscular status, such as the Optojump, which measures jump height and flight time during a CMJ protocol [14].

Regarding the well-being questionnaires to analyse and quantify the levels of fatigue perceived by the athletes, the Hooper index (HI) has been used [15]. The Hooper questionnaire is a self-reported questionnaire based on a 7-point scale. HI is determined as a result of the athlete's answer to 4 different questions (perceived feeling of stress, fatigue, delayed onset muscle soreness [DOMS], and sleep quality) [15]. Although there are other available questionnaires for assessing fatigue status, HI has been widely applied [16–18]. Furthermore, associations between well-being status and neuromuscular performance have been shown in other sports [19, 20]. In fact, 37 professional rugby players exhibited large to very large positive correlations between wellness and neuromuscular performance measures, which suggests the concurrent use of both the well-being questionnaire and jump test for fatigue monitoring [19].

These relationships are of extreme importance, as it may be argued that a lack of good levels of perceived well-being has negative effects on athletes' neuromuscular performance and readiness to train, which may lead to greater injury risks [21]. Previous studies dealing with seasonal changes in neuromuscular status in wrestlers implied that force values decreased in the middle of the season (MidS), but wrestlers' force increased before their most important competition [22]. Furthermore, a vertical jump power decrease was observed throughout the whole competitive wrestling season, mirrored by a decrease in resting total testosterone concentration [23]. However, there is still space for research on the effects of seasonal changes in neuromuscular status in wrestling athletes. That is why, and specifically on the basis of the findings of a previous study [24], which focused only on the over-season well-being variables patterns within a perspective of non-functional overreaching prevention and did not analyse performance aspects, the purposes of the present study were (1) to analyse the variations of CMJ performance over the different periods of the season and (2) to analyse the correlations between CMJ performance and well-being variables over the season periods.

Material and methods

Participants

This study was conducted with 10 elite young male freestyle wrestlers (mean ± standard deviation: age: 16.0 ± 0.7 years; height: 163.0 ± 4.8 cm; body weight: 57.7 ± 9.0 kg) participating in national and international competitions. Note that the data were obtained as part of a previously published study by Nobari et al. [24], who investigated the over-season well-being variable patterns with the specific aim of providing information to avoid the risk of injury, overtraining, and non-functional overreaching. This study involved athletes who regularly participated in competitions. They exercised at least 5 days a week. Since the wrestlers were accommodated in a camp centre, all conditions were equal. Nutrition, sleep, and other social life factors were the same.

Study design

This study had a long-term 32-week research design. The early period of the season (EarS) was weeks 1–11, MidS comprised weeks 12–22, and the end of the season (EndS) involved weeks 23–32. The athlete's wellness status examination included the parameters of daily fatigue, sleep, stress, and DOMS [15]. The CMJ test was applied before the athlete's warm-up and during each training.

Anthropometric measures

Standing height and body weight were measured (Seca model 654; Hamburg, Germany) with an accuracy of ± 5 mm per 1 m and 0.1 kg per 1 kg at the beginning of the study in the morning [17, 25]. The recommendations of the International Society for the Advancement of Kinanthropometry were considered during the measurements. Re-measurement was performed if the difference between 2 measurements exceeded 3%. In these cases, the median of the 3 measurements was used for further analysis [15].

Jump test

Before each testing session, the athletes followed a standard warm-up protocol, which involved stretching movements. The participants began to move with their legs fully extended, feet of the width of their choice, and hands on hips. They were told to jump as high as possible. It was stated that they should never pull their knees to themselves during the jump phase. The subjects had already practised the CMJ protocol in their past training, so they were familiar with this test. Before each training, the jump height was measured with Optojump Next (Microgate, Bolzano, Italy) jump measurement equipment.

Well-being status monitoring

HI was the sum of the answers to 4 different questions (concerning stress, fatigue, DOMS, and sleep quality) obtained from the athletes [10, 15] before the training [17, 18]. The individuals were familiar with the wellness status scales used in this study. While recording the data, they were asked and answered the questions individually. All data were stored in an Excel file.

Statistical analyses

Before starting the statistical analysis, the normality and homogeneity of the data were examined with the Shapiro-Wilk and Levene tests. After the normality test, it was determined that the CMJ values and well-being variables were normally distributed. Repeated measures analysis of variance (ANOVA) served to investigate the differences between periods within weeks, and Bonferroni post-hoc test was used for pairwise comparisons. Partial eta square (ηp^2) values were reported to indicate the effect size of repeated measures ANOVA. Hopkins' effect size statistics were applied to reveal the magnitude of the results obtained in the analyses. The limits used to interpret effect sizes are as follows: $\eta p^2 \leqslant 0.2$, trivial; $0.2 < \eta p^2 \leq 0.6$, small; $0.6 < \eta p^2 \leq 1.2$, moderate; $1.2 < \eta p^2 \leq 2.0$, large; $2.0 < \eta p^2 \leq 4.0$, very large; and $\eta p^2 > 4.0$, nearly perfect [26]. Since the data showed normal distribution, Pearson correlation analysis was performed between the CMJ neuromuscular fatigue indicators and well-being variables. The interpretation of the values obtained as a result of the correlations was made in accordance with the predetermined thresholds [26]: $d < 0.1$, trivial; $0.1 < d \leq 0.3$, small; $0.3 < d \leq 0.5$, moderate; $0.5 < d \leq 0.7$, large; $0.7 < d \leq 0.9$, very large; and $d > 0.9$, nearly perfect. For all the analyses, the statistical significance of the results was accepted at $p < 0.05$. All statistical calculations in the study were made by using Microsoft Excel.

Ethical approval

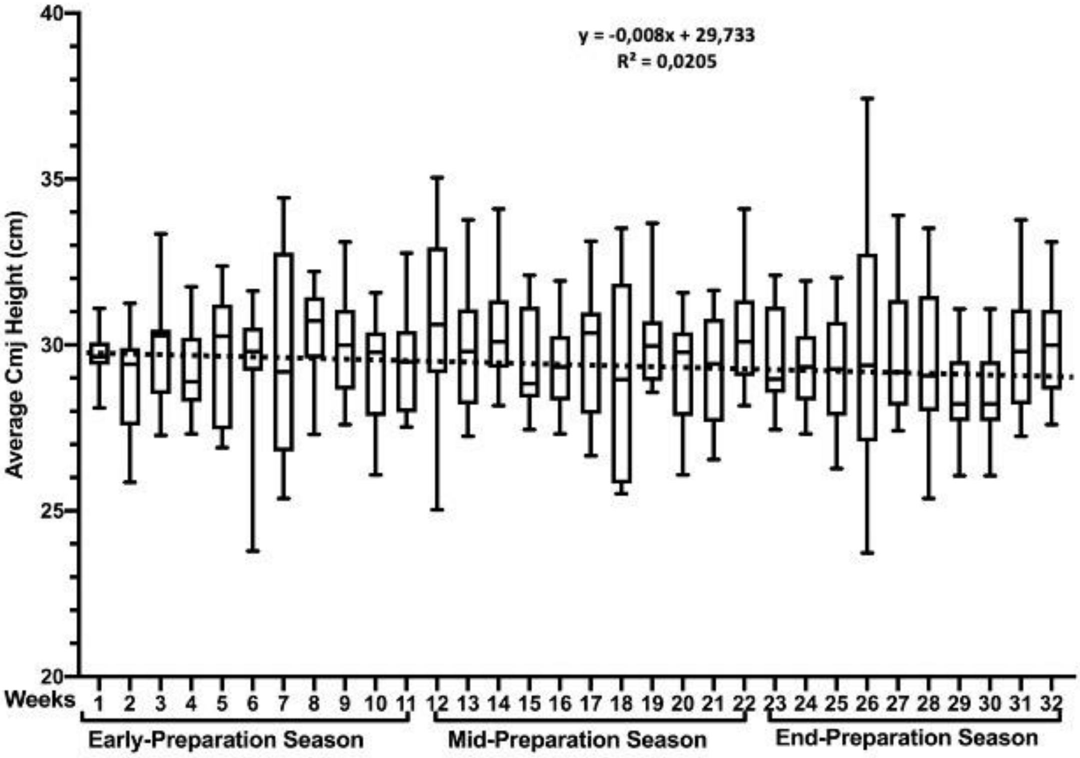
The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Afyon Kocatepe University Ethics Committee (approval No.: 2020/2).

Informed consent

Informed consent has been obtained from all individuals included in this study and their legal guardians.

Results

Weekly CMJ height fluctuated around 30 cm over the season. Figure 1 illustrates the summary of each season period for the neuromuscular variable (i.e., CMJ). The maximum (single) CMJ height (41.3 cm) was observed in EarS, whereas the minimum (37.5 cm) in EndS.



CMJ – countermovement jump

Figure 1. Box plots of CMJ height values (mean ± standard deviation)

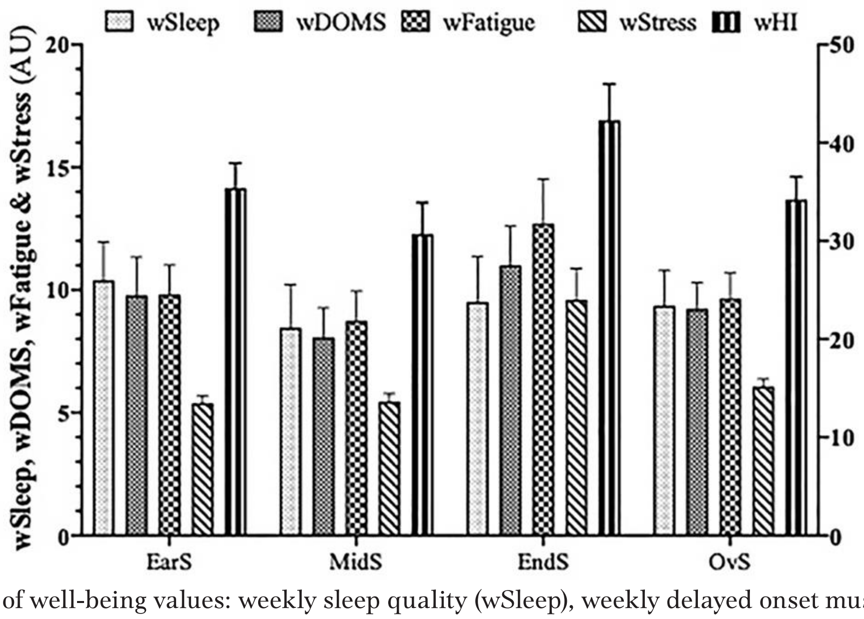


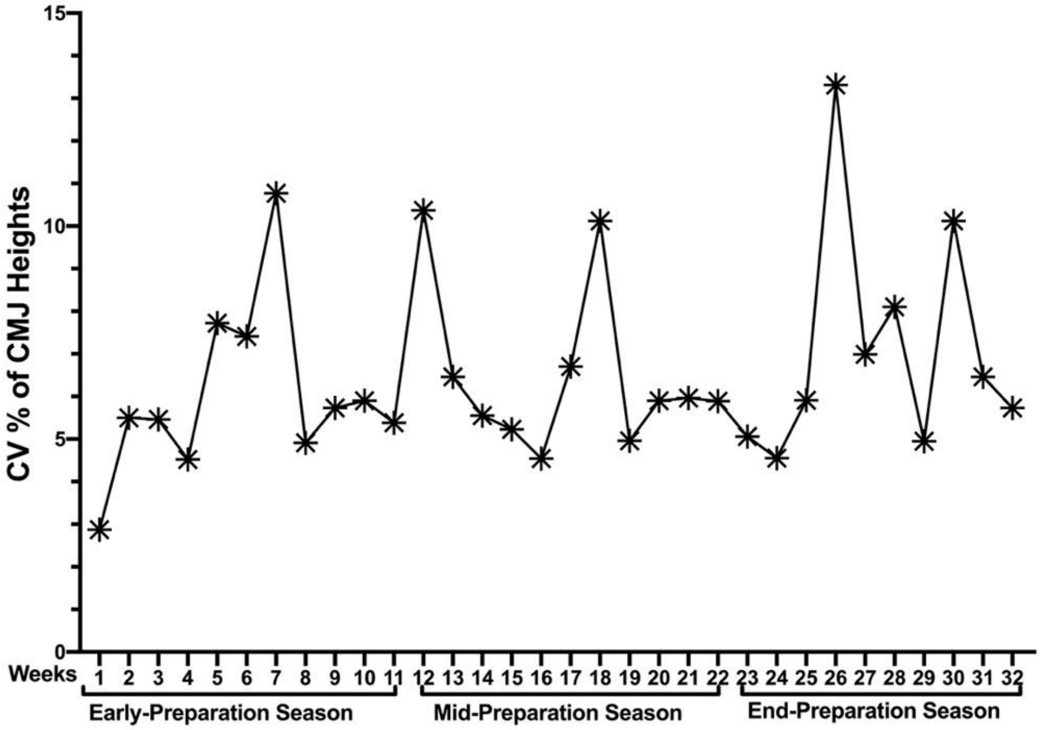
Figure 2. Summary of well-being values: weekly sleep quality (wSleep), weekly delayed onset muscle soreness (wDOMS), weekly fatigue (wFatigue), weekly stress (wStress), and weekly Hooper index (wHI), in arbitrary units (AU), indicated for early-preparation season (EarS), mid-preparation season (MidS), end-preparation season (EndS), and overall-preparation season (OvS). Data are shown as mean and standard deviation

Figure 2 shows the summary of well-being variables. The highest point recorded for weekly DOMS (wDOMS) occurred in EndS (11.1 ± 1.55), for weekly fatigue (wFatigue) in EndS (912.71 ± 1.82), for weekly stress (wStress) in EndS (9.60 ± 1.27), for weekly sleep (wSleep) in EarS (10.40 ± 1.56), and for weekly HI (wHI) in MidS (42.78 ± 3.71). In turn, the lowest point recorded for wDOMS occurred in MidS (8.07 ± 1.20), for wFatigue in MidS (8.75 ± 1.19), for wStress in EarS (5.39 ± 0.31), for wSleep in EndS (9.52 ± 1.83), and for wHI in MidS (30.71 ± 3.19).

Table 1. Comparison of countermovement jump variables between season periods

Period	Compared period	Mean difference	95% CI for mean difference		SE	t	Cohen's d	p
			Lower	Upper				
EarS	MidS	18.9	–19.1	57.0	13.3	1.4	0.44	> 0.999
	EndS	21.0	–17.0	59.1	13.3	1.5	0.49	0.762
	OvS	13.0	–25.0	51.2	13.7	0.9	0.30	> 0.999
MidS	EndS	2.1	–35.9	40.2	13.3	0.1	0.05	> 0.999
	OvS	–5.8	–43.9	32.2	13.3	–0.4	–0.13	> 0.999
EndS	OvS	–7.9	–46.0	30.1	13.3	–0.5	–0.18	> 0.999

EarS – early-preparation season, MidS – mid-preparation season, EndS – end-preparation season,
OvS – overall-preparation season



CV% – coefficient of variation, CMJ – countermovement jump

Figure 3. Seasonal and weekly CV% values

Table 1 presents the comparisons of CMJ values over different periods of the season. There was no statistically significant difference in CMJ (F = 0.084; p = 0.969). The lowest effect size for CMJ was 0.05, the highest effect size was 0.49. Figure 3 illustrates the summary of each season period coefficient of variation (CV%) of CMJ height. The maximum CV% (14%) was observed in EndS (week 26), whereas the minimum (3%) in EarS (week 1).

Tables 2 and 3 indicate the relationship between CMJ and HI variables over different periods of the season. No correlations were found between DOMS or fatigue and neuromuscular status over the different periods of the season. Small relationships of CMJ in EarS, MidS, and overall-preparation season with wHI during EarS and MidS were observed. Tables 4–8 report the remaining results.

Discussion

The purposes of the present study were to analyse the variations of CMJ performance over the different periods of the season and to analyse the correlations between CMJ performance and wellness variables over the season periods. The main finding was that no significant differences were noted regarding CMJ performance over the season periods (Table 1). The CMJ test values observed were in the lower range reported

Table 2. Correlation of delayed onset muscle soreness and fatigue with neuromuscular status over season periods (only relevant correlation coefficients are reported)

CMJ period	EarS-wDOMS	MidS-wDOMS	EndS-wDOMS	OvS-DOMS
EarS	–0.35			
MidS		0.08		
EndS			< 0.001	
OvS				0.00
CMJ period	EarS-wFatigue	MidS-wFatigue	EndS-wFatigue	OvS-Fatique
EarS	0.02			
MidS		< –0.001		
EndS			0.01	
OvS				0.01

CMJ – countermovement jump, EarS – early-preparation season, MidS – mid-preparation season, EndS – end-preparation season, OvS – overall-preparation season, wDOMS – weekly delayed onset muscle soreness, wFatigue – weekly fatigue

Table 3. Correlation of stress, sleep, and Hooper index with neuromuscular status over season periods (only relevant correlation coefficients are reported)

CMJ period	EarS-wStress	MidS-wStress	EndS-wStress	OvS-Stress
EarS	–0.03			
MidS		–0.03		
EndS			0.01	
OvS				–0.01
CMJ period	EarS-wSleep	MidS-wSleep	EndS-wSleep	OvS-Sleep
EarS	0.01			
MidS		< 0.001		
EndS			0.02	
OvS				0.01
CMJ period	EarS-wHI	MidS-wHI	EndS-wHI	OvS-HI
EarS	0.02*			
MidS		0.01		
EndS			0.01	
OvS				–0.08

* significant difference ($p < 0.05$)
CMJ – countermovement jump, EarS – early-preparation season, MidS – mid-preparation season, EndS – end-preparation season, OvS – overall-preparation season, wStress – weekly stress, wSleep – weekly sleep, wHI – weekly Hooper index

Table 4. Comparison of sleep variables between season periods

Period	Compared period	Mean difference	95% CI for mean difference		SE	t	p_{bonf}
			Lower	Upper			
EarS	MidS	–0.023	–0.240	0.193	0.090	–0.259	1.000
	EndS	–0.196	–0.412	0.021	0.090	–2.170	0.091
MidS	EndS	–0.172	–0.389	0.044	0.090	–1.910	0.169

EarS – early-preparation season, MidS – mid-preparation season, EndS – end-preparation season

Table 5. Comparison of delayed onset muscle soreness variables between season periods

Period	Compared period	Mean difference	95% CI for mean difference		SE	t	p_{bonf}
			Lower	Upper			
EarS	MidS	–0.157	–0.371	0.056	0.089	–1.769	0.232
	EndS	–0.113	–0.326	0.101	0.089	–1.267	0.617
MidS	EndS	0.045	–0.169	0.258	0.089	0.502	1.000

EarS – early-preparation season, MidS – mid-preparation season, EndS – end-preparation season

Table 6. Comparison of fatigue variables between season periods

Period	Compared period	Mean difference	95% CI for mean difference		SE	t	p_{bonf}
			Lower	Upper			
EarS	MidS	–0.055	–0.271	0.161	0.090	–0.614	1.000
	EndS	–0.072	–0.288	0.144	0.090	–0.803	1.000
MidS	EndS	–0.017	–0.233	0.199	0.090	–0.189	1.000

EarS – early-preparation season, MidS – mid-preparation season, EndS – end-preparation season

Table 7. Comparison of stress variables between season periods

Period	Compared period	Mean difference	95% CI for mean difference		SE	t	p_{bonf}
			Lower	Upper			
EarS	MidS	0.072	–0.151	0.296	0.093	0.777	1.000
	EndS	0.049	–0.174	0.272	0.093	0.525	1.000
MidS	EndS	–0.023	–0.247	0.200	0.093	–0.251	1.000

EarS – early-preparation season, MidS – mid-preparation season, EndS – end-preparation season

Table 8. Comparison of Hooper index variables between season periods

Period	Compared period	Mean difference	95% CI for mean difference		SE	t	p_{bonf}
			Lower	Upper			
EarS	MidS	–1.110	–4.645	2.425	1.464	–0.758	1.000
	EndS	–1.690	–5.225	1.845	1.464	–1.154	0.749
MidS	EndS	–0.580	–4.115	2.955	1.464	–0.396	1.000

EarS – early-preparation season, MidS – mid-preparation season, EndS – end-preparation season

in literature for junior athletes [2]. Such a discrepancy might result from the extraordinarily high level of the young Polish national-level subjects taken into account by Chaabene et al. [2]. DOMS, fatigue, stress, and sleep exhibited no relationships with neuromuscular status over the different periods of the season. Also, only a small relationship of neuromuscular status with wHI during EarS was determined.

Regarding the analysed weekly well-being variables, EndS showed the greatest values for the 5 well-being items (wSleep, wDOMS, wFatigue, wStress, and wHI), especially for wDOMS and wFatigue. In turn, the lowest CMJ heights were found during the EndS period. However, considering the first objective of the present study, the lack of significant differences in terms of CMJ performance over the different periods of the season seems to indicate an absence of neuromuscular fatigue. It is expected that week-to-week accumulated workloads throughout a season result in higher levels of fatigue during later stages of the season than at the beginning [10]. In fact, among rugby players, CMJ variables and well-being variables exhibited a declining pattern throughout a 12-week training period [20]. However, the CMJ protocol used was different than that applied in the present study, consisting in weighted jumps with a 20-kg Olympic bar.

Indeed, another study analysed which variables featuring CMJ performance (peak velocity, mean power, and jump height) were more sensitive indicators to monitor neuromuscular fatigue [27]. The authors found that peak velocity during the CMJ protocol was the variable showing the greatest sensitivity as a neuromuscular fatigue indicator. Given that, the lack of changes in CMJ performance throughout the wrestling season may be due to the use of the CMJ height variable, which may not be sensitive enough to track small changes. The difference between protocols (i.e., more fatiguing vs. one all-out exercise) may explain the difference observed in the present research compared with prior studies showing over-season neuromuscular status worsening [22, 23]. As freestyle wrestlers need to use leg explosive power-based actions during training and competition in a fatigued state [3, 6], it is of paramount importance to monitor even the smallest changes in neuromuscular performance on a weekly basis.

Considering the second objective of present study, it was observed that although no significant relationships were found between any of the individual wellness variables and neuromuscular status at different times of the season, the sum of all variables (wHI) presented significant associations with neuromuscular status. Despite the lack of studies analysing the relationships between neuromuscular performance and well-being variables for wrestling populations, other studies have documented relationships between neuromuscular performance and well-being variables with training loads [19, 28, 29]. In fact, in contrast to the present results, a study conducted among 35 professional rugby union players revealed large to very large relationships between wellness and neuromuscular variables [19]. The study analysed CMJ velocity measures and was performed in a sport different than wrestling, which makes the comparisons difficult. Another study, also carried out in professional rugby context, indicated that training loads had a clear effect on DOMS and neuromuscular performance [29]. Given that and considering the lack of relationships between neuromuscular performance and single well-being variables, it may be suggested that wrestlers analyse wHI instead of single well-being variables. In this regard, wrestling professionals should be aware that the existing literature on the validity of using composite variables such as wHI is still divergent in reporting various relationships with measures of training load, ranging from no to very large association [8]. Therefore, wrestling coaches could take into account the wHI patterns with caution to try ensuring adequate recovery strategies, especially in the final stages of the season. In the meantime, we are confident that this type of analysis will undergo further successful investigation in this specific population to make it possible to confirm the above findings.

The present study was not without limitations. The main limitation is related to the small sample size. The use of *p*-values as the main statistical source for detecting changes in neuromuscular performance during a CMJ protocol was another important issue. Given that the *p*-values may not be so sensitive to detect small changes and neuromuscular fatigue is highly sensitive to even small changes, it may be more advantageous for future studies conducted in wrestlers to apply the smallest worthwhile change together with the coefficient of variation analysis of CMJ measures. Similarly, as the use of jump velocity seems to be more sensible to neuromuscular fatigue, future studies performed among wrestlers should also employ jump velocity and more fatiguing protocols.

Conclusions

The main purpose of the present study was to analyse the variations of CMJ performance among the different periods of the season. The results revealed a lack of significant changes in neuromuscular performance throughout the season, suggesting the absence of neuromuscular fatigue. Secondly, this study intended to test the relationships between CMJ performance and wellness variables over the season periods. Despite a lack of significant relationships between single well-being variables and neuromuscular status, small significant relationships were found between wHI and neuromuscular status. Overall, practitioners might benefit from taking into account a sum of all well-being variables, such as wHI, to assess possible neuromuscular status changes in wrestlers, probably making use of fatiguing protocols as well.

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Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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