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Anthropometric characteristic and body composition of female students involved in volleyball training

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Abstract: There have been only few studies investigating the anthropometric characteristics of female volleyball players. These studies have revealed a positive influence of volleyball training on the physical development and fitness level among girls and women. The aim of the study was to assess the anthropometric profile of young female volleyball players.

Our sample consisted of twelve female volleyball players aged between 18-21 years with at least 5 years of training experience. The body height and mass, the thickness of skinfolds, longitudinal dimensions of the body, girth and breadths were measured. The body composition was determined using anthropometric and bioimpedance methods. Somatotype was determined according to the calculating method of J. E. L. Carter.

The body height of the volleyball players was estimated as high, and the body mass – higher than average. Middle shoulders, narrow pelvis and prevailing of longitudinal dimensions were the most distinctive features of the body proportions of the female volleyball players. Although their thorax was narrow, the respiratory muscles were well developed. The male type of proportions was typical for players exhibiting a theinoid scheme (middle shoulders, long legs) according to V.V. Bunak. Our data showed high development of the muscular component of the body of volleyball players, comparable to females professionally involved in sport . Index of muscle development, based on the excursion of the shoulder muscles, was typical for female athletes – 9,92 ± 2,98 cm. We also found that the relative mass of the fat component was within the normal range for elite volleyball players. The central somatotype was found to be typical for the female volleyball players: endomorphy – 3,98 ± 0,58, mesomorphy – 3,38 ± 1,01, and ectomorphy – 3,67 ± 0,76.

The obtained results describe the morphological profile of female volleyball players and can be used for the monitoring of their fitness level.

Key words: anthropometry, female players, playing positions, bioelectrical impedance, body proportions, Heath-Carter somatotype.

Original article

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Introduction

Volleyball is considered as one of the most popular sports and plays both the role of recreational activity and a professional sport. Anthropometry studies can provide important information regarding the influence of volleyball activities on the physical development of the younger population as well as asses sport selection processes and adaptation of professional volleyball players. Such studies have also the potential to determine the anthropometric characteristics of professional athletes, as well as estimate an influence of volleyball training on the physical development and fitness level of girls and women. Importantly, such studies can provide data that could be compared to anthropometric characteristics of other female athletes, such as those described in our previous research (Kutseryb et al. 2017; 2018; 2019; Hrynkiv et al. 2018).

Unfortunately, to our knowledge, there have been only few studies comparing anthropometric characteristics, such as somatotype and body composition, between female volleyball players and untrained students or young women (Tsunawake et al. 2003; Pietraszewska et al. 2015; Pastuszak et al. 2016; Sarafyniuk et al. 2018). These studies have revealed that, compared to students not actively involved in sport activities, volleyball players tended to be taller, while their circumferences of the arm and crus, most of the chest dimensions, body density, and lean body mass exhibited higher values. The above changes in physical development and fitness levels may be caused by volleyball training, resulting in the overall increase in shoulder width, circumferences of the chest and tensed shoulder, thigh and calf in young female volleyball players during one year training period (Sarafyniuk et al. 2020). The influence of the volleyball activities on anthropometric characteristics appears to be greater compared to other game sports. For example, young female handball players tended to be taller, had thinner skinfolds, lower body mass index and percentage of body fat compared to handball players (Konstantinos et al. 2019).

In the previously mentioned studies, the possible differences in the anthropometric profiles of the players of different positions were not considered. Such differences, possibly caused by variance in physical demands during a volleyball game (Fomin et al. 2012), were found for professional players by a number of studies (Zaccagni 2001; Malousaris et al. 2008; Carvajal et al. 2012; Gualdi-Russo & Martín-Matillas et al. 2014; Pietraszewska et al. 2015; Milić et al. 2017). In general, centers (middle blockers) and opposites (opposite heaters) are the tallest players with the largest ectomorphic component, while the liberos had the smallest body height and exhibited the highest mesomorphy. Differences in some somatotype categories influence the efficiency of young volleyball players (Grgantov Z. 2017). Although professional players have been found to exhibit significant differences in the anthropometric profiles, corresponding differences have not been investigated among college students. Therefore, the need for the creating an anthropometric model of college-level female athletes has been suggested, which would reflect the specificity of their sports activities. To address this issue, the present study aimed to examine the anthropometric profile of young female volleyball players.

Materials and methods

Study participants

We have examined 12 female athletes aged 18–21 years with sports experience of at least 5 years, players of Ivan Bobersky Lviv State University of Physical Culture (LSUPhC) volleyball team. A detailed description of the subjects is provided in Table 1. Informed consent was obtained before the study. All studies were provided with the ethical standards declared in the state documents and the internal regulations of the organizations responsible for the study with the participation of a human, as well as the principles of the declaration of the World Medical Association of Helsinki.

Data collection and statistical analysis

The following anthropometric characteristics were measured: body height (by anthropometer) and body mass (by Tanita BC 601), thickness of skinfolds (by Skinfold Caliper Baseline), longitudinal dimensions of the total body and the segments (trunk, lower and upper extremities), girths (circumferences) and breadths (diameters) (Martirosov 1982; Łaskia-Mierzejewska 2008). Chest girth (CG) was measured at rest, and at maximal inspiration and expiration (Martirosov 1982; Carter 1990; Malinowski & Bozitow 1997). Arm girth was measured in relaxed and tensed position.

Table 1. Main anthropometric characteristics of female volleyball players (n = 12)

Playing positions	Sport experience, years	Age, years	Body height, cm	Body mass, kg	CG, cm	CE, cm	BMI	IMD	BI
MB	7	19	182.0	70.5	85.0	7.0	18.7	6.3	49.1
MB	5	20	182.5	74.5	92.5	7.5	22.4	10.0	50.7
MB	8	21	181.7	76.8	85.1	6.0	19.8	7.7	46.8
OpH	13	20	180.1	76.6	87.2	7.9	20.0	11.5	48.2
OpH	8	18	179.9	65.9	86.8	7.0	20.5	8.1	48.5
OpH	8	18	179.9	65.9	85.1	7.0	20.4	11.5	47.5
S	6	19	178.2	68.0	87.0	4.5	19.8	11.5	48.7
S	8	18	177.1	69.1	88.0	8.3	20.7	8.0	48.9
OH	7	20	176.1	68.5	89.0	12.0	22.3	7.5	50.6
OH	5	20	175.2	69.1	95.0	5.0	21.7	7.1	54.3
L	10	20	172.4	59.4	97.0	7.0	23.7	10.0	56.4
L	5	20	170.1	61.00	82.5	10	20.0	9.8	47.9
Mean ± SEM	7.5±0.67	19.4 ±0.29	177.9 ±1.13	68.8 ±1.57	88.4 ±1.26	7.4 ±0.59	20.8 ±0.41	9.1 ±0.54	49.8 ±0.83

Notes: MB – middle blocker; OpH – opposite hitter; S – setter; OH – outside hitter; L – libero; CG – chest girth (at rest); CE – chest excursion; BMI – body mass index; IMD – index of muscles development; BI – Brugsch index.

Body composition was determined by both anthropometric and bioimpedance (Tanita BC 601) methods (Martirosov 1982; Martirosov et al. 2006), while physical development and body proportions were estimated by the index method. The Heath-Carter somatotype of athletes was determined by the calculation method of J. E. L. Carter (Carter 1990; 2002). Data were analyzed in Microsoft Excel 2010. All values are presented with arithmetic mean with standard error of the mean (SEM), in some cases the standard error (SE) of the data is shown.

Results

Body height of the study participants (see Table 1) was very high and exceeded the 97th percentile of 2000 CDC growth charts for healthy untrained subjects, while their body mass was higher than average (75th–90th percentiles). The tallest players were middle blockers (182.0 ± 3.30 cm) and the opposite hitters (180.1 ± 2.36 cm), while the smallest were liberos (172.4 ± 2.39 cm), which also had the lowest body mass. The mean value of body mass index (BMI) of volleyball players was 20.83 ± 1.41 kg/m^2, which is within 25th–50th percentile range for healthy untrained girls aged 18–20 years (2000 CDC growth charts 2002; Kuczmarski 2002). The values of chest girth (at rest, at maximal inspiration and expiration), Brugsch index, and chest excursion (see Table 1) indicated a good chest development of study participants.

The dimensions of the trunk and extremities of the players, such as lengths, breadths (diameters), and girths (circumferences) are presented in Table 2.

Table 2. Partial dimensions of the body of female volleyball players (n=12)

Dimensions, cm	Mean ± SEM
Trunk length	51.89±1.96
Arm length	79.38±2.59
Leg length	97.62±2.95
Biacromial breadth (diameter)	39.58±1.65
Transverse chest breadth	26.19±0.96
Anterior-posterior chest breadth	17.95±1.29
Biiliocristal breadth	28.08±1.49
Hand breadth	6.33±0.69
Wrist breadth	5.07±0.43
Femur breadth	9.46±0.64
Ankle breadth	6.39±0.80
Arm girth (circumference) (flexed and tensed)	29.23±2.45
Arm girth (relaxed)	26.58±1.95
Arm excursion	2.67±0.23
Forearm girth	24.27±1.58
Thigh girth	54.91±2.40
Leg girth	35.35±1.62

A comparison between athletes with different playing positions showed that middle blockers and the opposite hitters had the largest length of the trunk, upper extremities and lower extremities, with slightly lower values exhibited by setters and outside hitters, and the lowest values of the liberos. Thus, players of the attack line had larger values of the longitudal dimensions of the body's parts compared to players of the defensive line. We did not find any relationship between the playing role and the chest girth and chest excursion.

The index of lower extremities length (Sergienko 2004) and Manouvrier's skelic index (MSI, Łaskia-Mierzejewska 2008) showed that the examined players had long legs, combined with average shoulders width (by the index of shoulders width). The paratheinoid type of the body type with middle shoulders and long legs was found to be representative for the players (Martirosov 1982). The ratio of the biacromial to biiliocristal breadths of the subjects was 71.05 ± 1.29%, which clearly indicates a "male" type of body proportions.

The body composition of the athletes was determined by the anthropometric method and bioimpedance analysis (Table 3).

It should be noted that the bioimpedance analysis aims to show the mass of all human muscles (including smooth muscle and myocardium) and the mass of dry bone (Nikolaev et al. 2009). Due to this, the mean value of muscle component in our sample (47.00 ± 1.06 kg) was higher than the one obtained by the anthropometric method (29.49 ± 0.47 kg) and the dry bone mass – only 2.62 ± 0.09 kg. The fat component, determined by the bioimpedance method, was slightly higher (19.85 ± 2.34%), than obtained by the anthropometric one (16.39 ± 1.01%).

The thickness of subcutaneous fat layer on different body parts was analyzed by the skinfolds measurements and could be compared to the results of segmental bioimpedance analysis (Table 4). The average thickness of the subscapular skinfold was 12.58 ± 2.54 mm, abdominal – 18.25 ± 4.65 mm, suprailiac – 19.25 ± 4.63 mm. The triceps skinfold reached 13.50 ± 2.61 mm, biceps – 9.08 ± 2.91 mm, and the forearm one – 7.08 ± 2.50 mm. The thickness of the thigh skinfold was 15.25 ± 2.01 mm, and the medial calf one – 13.75 ± 2.86 mm. No significant difference was found between the players holding different volleyball positions, although there was a tendency towards slightly larger suprailiac, forearm skinfolds along with smaller subscapular skinfold for outside hitters and liberos.

Table 3. Body composition of female volleyball players (n = 12), determined by anthropometric and bioimpedance methods (Mean ± SEM)

Method	Bioimpedance method			
	Total muscles, kg	Bone mass, kg	Body fat, %	Visceral fat, %
Bioimpedance	47.00 ± 1.06	2.62 ± 0.09*	19.85 ± 2.34	1.67 ± 0.21
Anthropometric	29.49 ± 0.47**	9.94 ± 0.41	16.39 ± 1.01	–

Notes: * – dry bone mass; ** – skeletal muscles only.

Table 4. Results of segmental bioimpedance analysis (n=12, mean ± SEM)

Index	Total muscles, kg				
	Trunk	Right hand	Right leg	Left hand	Left leg
Total muscles, kg	26.76 ±0.74	2.71 ±0.20	8.97 ±0.26	2.73 ±0.16	8.87 ±0.25
Body fat, %	22.39 ±1.38	19.66 ±2.20	26.25 ±1.57	19.06 ±1.45	25.97 ±1.57

Both the results of segmental bioimpedance analysis and anthropometric data showed a high development of the lower extremity muscles of the examined players that was confirmed by high girths of thigh and calf (see Table 2), small thickness of relevant skinfolds (see above), and a high mass of leg muscles (see Table 4). As expected, there was no significant bilateral asymmetry in the muscle and fat components of the extremities.

The analysis of the Heath-Carter somatotype of players (Carter 1990) revealed significant individual differences in the values of some components (Fig. 1) which might be related the specific demands of different playing positions, though a larger data set is needed for these results to be conclusive. For example, the somatotype of both liberos was ectomorphic endomorph, and outside hitters – mesomorph-endomorph. Other players were generally more ectomorphic, especially the middle blockers and opposite hitters.

We found the following average values for somatotype components of the

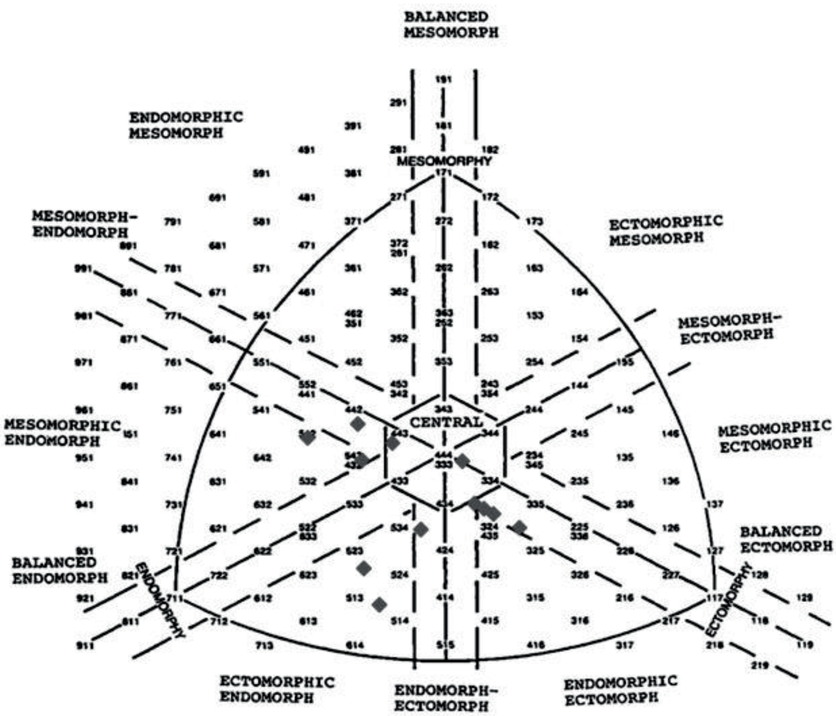

Fig. 1. Individual somatotypes of female volleyball players according to Heath-Carter

players: endomorphy – 3,98 ± 0,58, mesomorphy – 3,38 ± 1,01, and ectomorphy – 3,67 ± 0,76. As all somatotype components are close to average levels, and the difference between them does not exceed 1 point, it indicates the central type of constitution. The obtained values of ectomorphic and endomorphic components are caused by a combination of large height and long legs of players with the average body mass and average thigh girth.

Discussion

The body height and mass of study participants of our study are similar to those reported in other studies. For instance, the body height of female volleyball players was reported to range from 169.2 to 187.1 cm (Carvajal et al. 2012; D'Anastasio 2019) and body mass – from 79.0 to 60.7 kg (Carvajal et al. 2012; D'Anastasio 2019). The elite players tend to be higher – from 177.1 to 187.1 cm (Malousaris et al. 2008; Carvajal et al. 2012) in comparison to non-professional athletes (168.7–177.9 cm) (Tsunawake et al. 2003; Buśko 2012). Consequently, the height of participant in our study falls within the upper range for college players, and the lower level for top-level athletes. The body mass of the elite players (63.7–79.0 kg) is also higher compared to players of college teams (59.7–71.3 kg) (Tsunawake 2003; Buśko 2012; Bozo and Lleshi 2012; Carvajal et al. 2012). Therefore, body mass observed among study participants corresponds to average values of top-level athletes and above average values of college players. The BMI of study participants (20.83) is comparable to those of other college players (20.0–22.5) and lower than BMI of elite players (22.0–23.2) (Bozo and Lleshi 2012; Buśko 2012; Carvajal et al. 2012, 2015). The larger values of BMI of the top-level players could be the result of higher development of skeletal muscles.

There have been plenty of studies looking at the variance in the height and body mass between the professional players of different positions (Malousaris et al. 2008; Carvajal et al. 2012; Martín-Matillas et al. 2014; Pietraszewska et al. 2015; D'Anastasio 2019). In support of their findings, we have found that middle blockers (181.7–182.0 cm) are the tallest players, while the opposite hitters, setters and outside hitters are slightly smaller, and the smallest height is exhibited by liberos (170.1–172.4 cm). Liberos also have the lowest body mass (59.4–61.0 kg), as compared to athletes of the other playing positions (65.9–76.8 kg). The differences in the total sizes of the athlete's body can be explained by the peculiarities of the activity of each playing position. Our results suggest that the pronounced morphological adaptation of the players to the demands of different playing positions might be detected even at the level of college (university) teams.

The chest girth of our subjects (88.35 ± 4.36 cm) highly exceeds the data presented by Tsunawake et al. (2003) – 82.8 cm, and appears to be comparable to chest girth of elite players (89.1–90.5) (Carvajal et al. 2015). A pronounced chest development of study participants is also indicated by Brugsch index, which is high (49.80 ± 2.86) and similar to the normal level for men (50–55 units). Chest excursion (7.43 ± 2.04 cm) appears to be within the normal range for female athletes. The anterior-posterior chest breadth (26.2 cm) is comparable to top-level athletes (26.3–26.5 cm; Carvajal et al. 2012).

The average arm length of the examined volleyball players (79.4 cm) is comparable to results reported by other researchers (Sarafyniuk et al. 2020), and larger compared to basketball players (Hrynkiv 2018). The width of the shoulders (39.6 cm) and pelvis (28.1 cm) of study participants is rather average compared to elite players reported by other studies (39.2–40.9 cm and 27.6–33.1 respectively; Papadopoulou 2003; Carvajal et al. 2015). Examined players have paratheinoid type of body, the "male" type of body proportions (larger biacromial than the biiliocristal breadth), and highly developed legs' muscles. These features indicate an optimal adaptation to vertical jumps, which is incredibly important in the volleyball.

The breadth of the hand (6.33 cm), wrist (5.07 cm), femur (9.46 cm), and ankle (6.39 cm) of examined players in most cases are slightly lower compared to the corresponding values of top-level players (6.2–7.1; 5.3–5.4; 9.6–9.9; 6.8–7.4 cm respectively) (Papadopoulou 2003; Carvajal et al. 2012; 2015; Pietraszewska et al. 2015), suggesting that the adaptive changes in the skeletal system are less pronounced at the level of college players in comparison to the elite athletes.

The circumferential dimensions of some body parts (i.e., girth of the forearm, thigh, and leg), the girth of flexed and tensed arm, the strength index and index of muscle development can be used as an indicator of skeletal muscles development. This is supported by the findings of other studies (Papadopoulou 2002, 2003; Carvajal et al. 2012; 2015; Martín-Matillas et al. 2014) showing that the highest values of circumferences of arm (relaxed – 28.5, flexed – 30.5 cm), forearm (25.9 cm), thigh (60.1 cm), and leg (37.7) of the elite female volleyball players exceed the corresponding values of the college teams' players (26.6–29.2; 24.3; 54.9; 36.5 cm respectively). It also indicates the importance of high muscles development necessary to enhance volleyball performance. The circumferential dimensions of the examined players appear to fall within the lower part of the range for the elite athletes, while the difference in the girth of flexed and tensed arm of our subjects (2.67 cm) exceeds the maximal level of top players (2.1 cm, Carvajal et al. 2015). We found that the strength index of the examined volleyball players (48.99 ± 3.68%) lies within the range for female athletes (50–60%). The index of muscle development of study participants is 9.92 ± 2.98%, while for the basketball players it is considerably lower – 5.38 ± 1.13%, exhibiting typical values for female athletes are 5–12% (Malinowski and Bozitow 1997; Łaska-Mierzejewska 2008; Hrynkiv et al. 2018; Kutseryb et al. 2019). Our results suggest that development of the skeletal muscles of our subjects is comparable to the top-level players.

The fat component of our study participants (16.4%), determined by the skinfold measurements, is close to the lowest values, reported both for the high-skilled (14.9–28.9%) and college-level (13.99–25.6%) female players (Bozo and Lleshi 2012; Carvajal et al. 2012; Buśko 2012). The thickness of skinfolds might indicate differences regarding the development of subcutaneous fat layer for examined players compared to highly qualified athletes. Similar values are found for the number of skinfolds: subscapular (12.1 mm compared to 9.5–12.3 mm), triceps (13.5 and 9.6–19.3 mm), thigh (15.25 and 10.0–19.0 mm), and medial (13.75 and 7.6–17.4) (Papadopoulou

2002; Malousaris et al. 2008; Carvajal et al. 2012; 2015). However, some other skinfolds, such as abdominal (18.25 compared to 10.6–12.6 mm), suprailiac (19.25 and 6–10.9 mm), and biceps (9.08 compared to 4.5–5.9 mm) are thicker in the participants of this study.

A higher level of relative fat mass (19.85 ± 8.09%) is observed among study participants using the bioimpedance method. It includes 1.67 ± 0.73% of visceral fat, a sufficient amount of which could play an important role in terms of the fitness and health of female athletes. It is widely assumed that visceral adipose tissue in omentums and adipose capsule of the kidneys ensures proper fixation of internal organs and cushioning of the mechanical shocks during the run and jump performance.

The relative mass of the bone component (15.13%), showed in our study using the athropometric method, is higher compared to high-skilled female players (8.9–9.5%, Carvajal et al. 2012). The bioimpedance analysis reveals a dry bone mass of 2.62 kg. Given that the average body mass of the study participants is 65.66 kg, these values of the bone component are within a normal range (Nikolaev et al. 2009).

The muscular component of examined volleyball players reaches 44.93% of body mass, while in other studies it was reported to vary from 37.8% (Martín-Matillas et al. 2014) to 45.9% (Carvajal et al. 2012) for the elite female players, supporting the results of our study regarding the high development of the skeletal muscles.

The average somatotype of our study participants is the central one (endomorphy – 3.98 ± 0.58, mesomorphy – 3.38 ± 1.01, and ectomorphy – 3.67 ± 0.76). The endomorphy level of elite female volleyball players ranges between 2.4 and 3.4 (Carvajal et al. 2015; Malousaris et al. 2008), and in one case it reaches 4.25 (Papadopoulou 2002). The mesomorphy of elite athletes was found to vary from 2.2 to 3.5 (Papadopoulou 2002; Carvajal et al. 2015), and ectomorphy – from 2.9 to 3.2 (Malousaris et al. 2008; Carvajal et al. 2012; 2015). The average somatotype of top-level female players, calculated as the mean of the data of other authors (Papadopoulou 2002; Malousaris et al. 2008; Carvajal et al. 2012, 2015; Martín-Matillas et al. 2014), is estimated to be 2.91–3.24–2.96 (endomorphy – 2.91 ± 0.16, mesomorphy – 3.24 ± 0.13, and ectomorphy – 2.96 ± 0.08). It shows that top-level female players also have central somatotype, although our study participants have larger endomorphy and smaller ectomorphy levels.

In summary, the results of our study reveal a significant influence of the training activities on the female physique, though not as large as professional sport activities. Our study participants are much taller and exhibit higher body mass and BMI compared to untrained persons, and these features to a great extent depend on playing position. however, the above differences in body physique are less pronounced than in professional athletes. Still, the examined players exhibit well-developed chest and shoulders, parathenoid type of body proportions and the “male” body type. Development of the skeletal muscles among study participants is comparable to the top-level players. The muscular component of their body composition is high (44.93 ± 1.52%), while the fat component (16.4%) is close to the lowest values of volleyball players. The average somatotype of examined volleyball players is central type (3.98–3.38–3.67), although significant individual differences in the values of the three components of the constitution have been found.

We suggest that the obtained data allow us to recommend volleyball training for the improvement of the physical development of women. The knowledge of the morphological profile of the female volleyball players, described in our study, will facilitate the selection of the players for the volleyball teams and will improve the individual approach to athletes' training during regular, pre-competitive and main competition periods.

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Conflict of interests

The authors confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Authors' contributions

TK, MH, FM – conceived and designed the analysis, collected the data, performed the analysis and wrote the manuscript; LV – performed the analysis and wrote the manuscript; VM – collected the data and wrote the manuscript. All authors discussed the results and contributed to the final manuscript.

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