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Detection of female volleyball player body composition using bioelectric impedance analysis: cross-sectional study

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Abstract

Purpose: In today's sport, and especially in high-performance sports where volleyball also belongs, continuous monitoring of Body Composition (BC) can significantly regulate the training process, which has a positive effect on the top form of athletes. Aim of the current study was to assess and analyze the body composition of a female volleyball players VC "Jahorina", by Bioelectric Impedance Analysis (BIA).
Material and methods: In study the participants consist 18 female volleyball players, the members of the Volleyball Club ''Jahorina'' from Pale, East Sarajevo City (Body height = 173 ± 8.77 cm; Body weight = 66.04 ± 9.09kg; BMI = 22.03 ± 2.19 kg/m², decimal age 19.11 ± 2.63 years old) who competes in the Premier League of Bosnia and Herzegovina (B&H).
Results: of the study showed that the body composition is within the healthy (allowed) values recommended for this population of volleyball players (Body Fat = 24.82%; Body Fat=11.44kg; Body Water = 53.68%; Body Muscle = 47.09 kg, BMR = 1538.08; DCI = 6435.38, etc.).
Conclusion: Compared to the results of other authors, that Jahorina volleyball players do not lag far behind European clubs in terms of weaker BC (BF%, BFkg, BW%, BMkg, BMR, DCI, BMI, etc.). The only place where they are inferior is the body height of the volleyball player (height = 173 ± 8.77 cm), while the relative value of Body weight = 66.04 ± 9.09 kg is evident.
Key words: female volleyball players, body composition, bioelectric impedance analysis, detection

Анотація

Ратко Павлович, Владан Савич, Нікола Радулович, Ірина Скрипченко. Визначення складу тіла волейболісток за допомогою аналізу біоелектричного імпедансу: перехресне дослідження
Мета: У сучасному спорті найвищих досягнень, зокрема у волейболі, регулярний моніторинг складу тіла дозволяє суттєво регулювати тренувальний процес, що позитивно позначається на спортивній формі гравців. Метою цього дослідження стала оцінка та аналіз складу тіла волейболісток ВК «Яхорина» методом біоімпедансного аналізу.
Матеріали та методи: У дослідженні взяли участь 18 волейболісток, членів волейбольного клубу «Яхорина» з міста Пале у Східному Сараєві (зростання = 173 ± 8,77 см; маса тіла = 66,04 ± 9,09 кг; ІМТ = 22,03 ± 2,19 кг/м², середній вік 19,11 ± 2,63 роки), які виступають у Прем'єр-лізі Боснії та Герцеговини.
Результати: дослідження показали, що склад тіла знаходиться в межах допустимих значень для даного контингенту здорових волейболістів, з відповідними показниками (жирова маса = 24,82%; маса жиру = 11,44 кг; відсоток води в організмі = 53,68%; м'язова маса тіла = 47,09 кг, базальна швидкість обміну речовин (BMR) = 1538,08, добова норма калорій (DCI) = 6435,38 тощо).
Висновок: У порівнянні з результатами інших авторів, волейболісти ВК «Яхорина» не суттєво відрізняються від європейських клубів за більшістю показників (BF%, BFkg, BW%, BMkg, BMR, DCI, BMI тощо). Єдине місце, де вони суттєво поступаються – це довжина тіла волейболіста (довжина тіла = 173±8,77 см), при цьому відносна величина маси тіла становить 66,04±9,09 кг.
Ключові слова: волейболістки, склад тіла, біоімпедансний аналіз, дослідження

Аннотация

Ратко Павлович, Владан Савич, Никола Радулович, Ирина Скрипченко. Определение состава тела волейболисток с помощью анализа биоэлектрического импеданса: перекресное исследование
Цель: В современном спорте высших достижений, в частности в волейболе, регулярный мониторинг состава тела позволяет существенно регулировать тренировочный процесс, что положительно сказывается на спортивной форме игроков. Целью настоящего исследования явилась оценка и анализ состава тела волейболисток ВК «Яхорина» методом биоимпедансного анализа.
Материалы и методы: В исследовании приняли участие 18 волейболисток, членов волейбольного клуба «Яхорина» из города Пале в Восточном Сараево (рост = 173 ± 8,77 см; масса тела = 66,04 ± 9,09 кг; ИМТ = 22,03 ± 2,19 кг/м², средний возраст 19,11 ± 2,63 года), которые выступают в Премьер-лиге Боснии и Герцеговины.
Результаты: исследования показали, что состав тела находится в пределах допустимых значений для данного контингента здоровых волейболистов, с соответствующими показателями (жировая масса = 24,82%; масса жира = 11,44 кг; процент воды в организме = 53,68%; мышечная масса тела = 47,09 кг, базальная скорость обмена веществ (BMR) = 1538,08, суточная норма калорий (DCI) = 6435,38 и т. д.).
Вывод: По сравнению с результатами других авторов, волейболисты ВК «Яхорина» не существенно отстают от европейских клубов по большинству показателей (BF%, BFkg, BW%, BMkg, BMR, DCI, BMI и т. д.). Единственное место, где они существенно уступают - это длина тела волейболиста (длина тела = 173 ± 8,77 см), при этом относительная величина массы тела составляет 66,04 ± 9,09 кг.
Ключевые слова: волейболистки, состав тела, биоимпедансный анализ, исследование

Introduction

Volleyball is nowadays one of the most popular team sports in the world, with more than 200 volleyball nations. It is expanding and competing with high physical, technical and tactical performance [1]. It is an intermittent sport that requires high intensity and short-term activities intertwined with periods of low intensity [2, 3, 4]

Intensive activities such as jumps, steps, blocks, various landings, multidirectional movements, with short recovery periods are performed during the game [5]. The volleyball game is fast and dynamic, which requires good agility, fast and explosive movements on and off the volleyball court. Unlike other collective sports, only in volleyball there is no time limit, so the duration of the match can be 2-3 hours with dehydration present. Therefore, players should have good strength associated with the total amount of water in the body (hydration), because any loss of water in the muscles leads to a decrease in strength, which negatively manifests itself on the game and the result [6].

From the sports aspect, successful volleyball requires a high level of technical and tactical performance, motor and mental abilities [7, 8] and as such they should be aligned with anthropometric characteristics and body composition [9, 10]. Along with individual physical capacities, the most important factors are the ones that contribute to the success of a team in major competitions [11]. According to some research [12, 13], kinanthropometric assessment in volleyball is especially important, as volleyball players have been shown to possess exceptional muscle strength, horizontal and vertical explosiveness, block jump strength and height, power and speed for spiking on the net, agility, speed endurance, which is correlated with the technical and tactical requirements of the game. Therefore, any increase in body weight negatively affects the motor structure of the player, because it leads to motor imbalance and technical performance of the elements of volleyball [14]. All of the above motor skills include players with less body fat, as changes in muscle mass or fat percentage have been shown to be associated with volleyball success [15]. In all of this, morphological parameters, along with physical status, play a vital role in predicting volleyball success [4, 16, 17].

In most cases, all sports, as the most important component, list body fat due to the negative association with numerous abilities (explosive power, speed, flexibility, agility…). Body fat, as one segment of body status, is a disruptive factor in many sports that overcome the force of gravity, including volleyball. It is an indisputable fact that the increased body weight of volleyball players, followed by increased adipose fat tissue, also has a disruptive role in specific volleyball activities (height of jumps in jumps, jumps in blocks), influencing sports results [18]. Excessive amount of adipose tissue is considered unused mass, because the athlete's body repeatedly struggles with gravity during movement and jumps [19], which results in reduced performance and increased energy requirements during certain activities, which is characteristic of volleyball. Lean body mass, which includes lean muscle mass and bone mineral mass, is important for producing speed, strength, power, and injury prevention [20]. According to Andreola, Melchiorri, Brozzi, ..., & De Lorenzo [21], body composition indicators are the best predictors of muscle efficiency that can predict sports volleyball performance. Precisely because of this, body composition is considered to be one of the components of an athlete's physical fitness. Body composition undergoes individual changes, depending on age, gender, physical activity and sport, somatotype, genetics as well as intra-individual variability. From a biological perspective, there are changes not only in weight but also in endogenous aspects (lean body mass, fat mass, water, bone density, basal metabolism, etc.) testifying to the internal composition of the organism [22].

In general, high body fat values are undesirable for high physical performance in sports that require running and jumping. According to Heyward, & Stolarczyk [23] for female players, the minimum body fat should not be less than 12-16%, depending on the sport. Typical values for elite women range from 12% to 20% (24) and 16-25%, respectively) [6]. With less than this level there is an athletic risk of amenorrhea leading to bone mineral loss. In elite sport, continuous monitoring of physical status significantly regulates the training process and thus positively affects the top form of athletes [22, 25]. Questions regarding body composure in volleyball are the subject of previous research and are often associated with different levels of women's skills [22, 26, 27-33].

Bioelectrical impedance analysis (BIA) is used in studies to assess body composition parameters (e.g. total extracellular, intracellular water compartments, fat mass, body mass, resistance and basal metabolism). Its use is has become more and more popular since it is safe, non-invasive, fast, easy to use and suitable for laboratory, clinical and field assessments of human body composition [34]. The obtained information on body composition is multifunctional and can be used in different cases: determining differences between competition levels

[8], levels for assessing the optimal body weight of athletes and the corresponding somatotype for volleyball [16], as a supplement to the physiological profile of volleyball players [35], it can become an indicator of athlete diet and provide facts about the current homeostasis of body fluids [21], become an incentive to recommend a change in regimen the nutrition of volleyball players [36] or it can be the incentive for adequate supplementation after sports competition as part of adequate physical fitness [37], etc. Given the data contained in the analysis of body composition, it can rightly be said that this is the so-called body map of the athlete.

Anthropometric measurements and measurements of physical status are widely used to assess and predict performance and models in various sports, including volleyball. It is necessary to have a model of all other spaces of interest for issues of sports training, selection and different ages of athletes, in relation to different levels of competition or position in the team [38]. Monitoring and assessing physical status can be helpful in determining the appropriate amount of training work in designing athlete load diagnostics. In this regard, assessing the physical composition of volleyball players is one of the important tasks for both coaches and players. In women's volleyball, the Premier League of Bosnia and Herzegovina, research of this kind is mostly lacking, as well as empirical findings on possible results of physical status by analysis of bioelectrical impedance, which is one of the starting problems of this research. The main goal of the study was to assess and analyze the physical status of the volleyball players of VC "Jahorina", a member of the volleyball Premier League of Bosnia and Herzegovina, by analyzing the Bioelectric Impedance (BIA).

Material and methods

Participants of study

The sample of participants consist 18 female volleyball players, the members of the Volleyball Club "Jahorina" from Pale, East Sarajevo city (Body height=173±8.77cm; Body weight=66.04± 9.09 kg; BMI=22.03±2.19kg/m², decimal age 19.11± 2.63 years old) who competes in the Premier League of Bosnia and Herzegovina (B&H). A total of 18 variables were measured to assess BC:

1. Body fat (%)
2. Body fat (kg)
3. Body water (%)
4. Body muscle (kg)
5. Right hand muscle (kg)
6. Left hand muscle (kg)
7. Trunk muscle (kg)
8. Right leg muscle (kg)
9. Left leg muscle (kg)
10. Right hand fat (%)
11. Left hand fat (%)
12. Trunk fat (%)
13. Right leg fat (%)
14. Left leg fat (%)
15. Viscelar fat
16. Bones (kg)
17. Basal metabolic rate-BMR (kCal)
18. Daily calorie intake-DCI (kCal)

Experimental design

This study followed a cross-selectional design. Convenience sampling was performed. The standard metric instruments were applied according to the methodology of the International Society for the Advancment of Kinanthropometry. Stadiometer-used for measuring body height (SECA 206, Germany). Body weight and Body composition (BC) were assessed with the Bioelectrical Impedance Analysis (BIA) using a body composition analyser (Tanita Inner ScanV BC-545N, Tokyo, JAPAN), in accordance with the measurement protocol. All measurements were conducted during regular training at April 2021. During the testing, the air temperature was between 18°- 22°C. The participants were informed in detail about the nature of the study and investigational procedures, and all the participants have voluntarily given their consent to be the part of this study. Prior to the survey, each respondent signed a consent form to participate. The measurements were according to the procedures in the Helsinki declaration.

Bioelectrical Impedance Analysis-BIA [39]

Body composition monitor was used to assess the variables of body composition of the participants. It is a device that measures the body weight, body fat percent, visceral fat, skeletal muscle mass, and resting metabolic rate which works according to Bioelectrical Impedance Analysis (BIA) which analyzes the electrical resistance of the body tissues by sending extremely weak electrical current through the body. The following procedures were used for the measurement:

1. The power switch was press to turn on the machine the input button was pressed to enter each participant's age, height and sex;

2. Each participant mounted the machine, bear footed placing the sole on the electrode of the machine;

3. Raise your arms horizontally and extend your elbows straight to form a 90° angle to your Body;

4. Stand with your knees and back straight and look straight ahead;

5. Hold the display unit in front of you;

6. Step on the Main Unit barefoot;

7. Make sure the heels are positioned on the heel electrodes and

8. Stand with your weight evenly distributed on the measurement platform.

Data analysis

The descriptive statistic were calculated. The statistical package Statistica, version 10.0 (STA999k347150-W) was used for data processing.

Results

The presents the central statistical parameters of the BC of the analyzed sample of Jahorina female volleyball player (Table 1. Figure 1). The results confirmed that body fat determines 24.82 ± 3.71% (18.10-34.60%) of body composition, which is 11.44±2.30 kg of fat mass (10.90-15.90 kg). Of the total body mass of the sample (66.04 kg), muscle mass is contained in 47.09 ± 6.63 kg (35.50-60.20 kg), while bones as part of the skeleton and total body mass take part with 2.5 kg (1.90-3,20kg) which is an indicator of the appropriate mineral status of the bones of the organism.

Table 1

Descriptive statistics Body composition

Variables	Mean	Min	Max	Range	Con-SD % -95,00 to 95,00	CV%
Body fat (%)	24,82±3,71	18,10	34,60	16,50	3,38-7,77	18,24
Body fat (kg)	11,44±2,30	10,90	15,90	5,00	1,86-5,21	13,99
Body water (%)	53,68±6,42	35,20	60,20	25,00	4,60-10,60	11,96
Body muscle (kg)	47,09±6,63	35,50	60,50	25,00	4,76-10,95	14,08
Right arm muscle (kg)	2,43±0,43	1,70	3,30	1,60	0,30-0,70	17,48
Left arm muscle (kg)	2,35±0,45	1,60	3,30	1,70	0,32-0,74	19,19
Trunk muscle (kg)	25,70±6,82	5,80	34,50	28,70	4,89-11,26	26,54
Right leg muscle (kg)	7,81±1,06	5,70	9,90	4,20	0,76-1,76	13,63
Left leg muscle (kg)	7,64±0,99	5,70	9,50	3,80	0,71-1,63	12,92
Right arm fat (%)	21,64±3,55	16,30	26,30	10,00	2,55-5,86	16,42
Left arm fat (%)	24,48±4,05	18,80	30,60	11,80	2,91-6,69	16,55
Trunk muscle (%)	22,95±6,34	12,90	34,60	21,70	4,55-10,47	27,63
Right leg fat (%)	31,08±3,48	23,80	36,90	13,10	2,50-5,75	11,21
Left leg fat (%)	31,14±3,57	22,80	36,60	13,80	2,56-5,89	11,47
Viscelar fat	1,38±0,58	1,00	2,50	1,50	0,42-0,96	42,10
Bones (kg)	2,51±0,34	1,90	3,20	1,30	0,24-13,37	13,37
Basal metabolism (kCal)	1538,08±202,42	1174,00	1944,00	770,00	145,15-334,14	13,16
Daily calorie intake-DCI (kCal)	6435,38±847,01	4912,00	8134,00	3222,00	607,38-1398,18	13,16

It is evident that numerical analysis of segmental muscle status defines significant symmetry between the left and right sides of the cranial and caudal extremities. The right arm 2.43kg (1.70-3.30kg) contains slightly more muscle mass than the left arm 2.35kg (1.60-3.30kg) and the right leg 7.81kg (5.70-9.90kg) also in relation to the left leg 7.64kg (5.70-9.50kg). The largest muscle mass is present in the torso 25.70 kg (5.80-34.50 kg). Regarding the average representation of adipose tissue (%) of female volleyball players, slightly higher percentage differences between the extremities of the left and right sides of the body are evident. They generally maintain an inverse relationship with muscle tissue values as expected. The right arm contains an average of 21.64% adipose tissue (16.0-26.30%) and is less than the fat percentage of the left arm 24.48% (18.80-30.60%).

The proportion of adipose tissue in the caudal extremities recorded identical average values (right leg, 31.08% vs. left leg 31.14%) as well as ranges of min. and max. results. Carcass fat content contains close to 23% (12.90-34.60%), which is within healthy limits, without the possibility of amenorrhea with loss of minerals in the bone. Body composition reflects a slight heterogeneity within the

sample (CV%), which may be due to poorer selection when selecting contestants, age differences, biological acceleration, physical fitness, playing positions, etc.

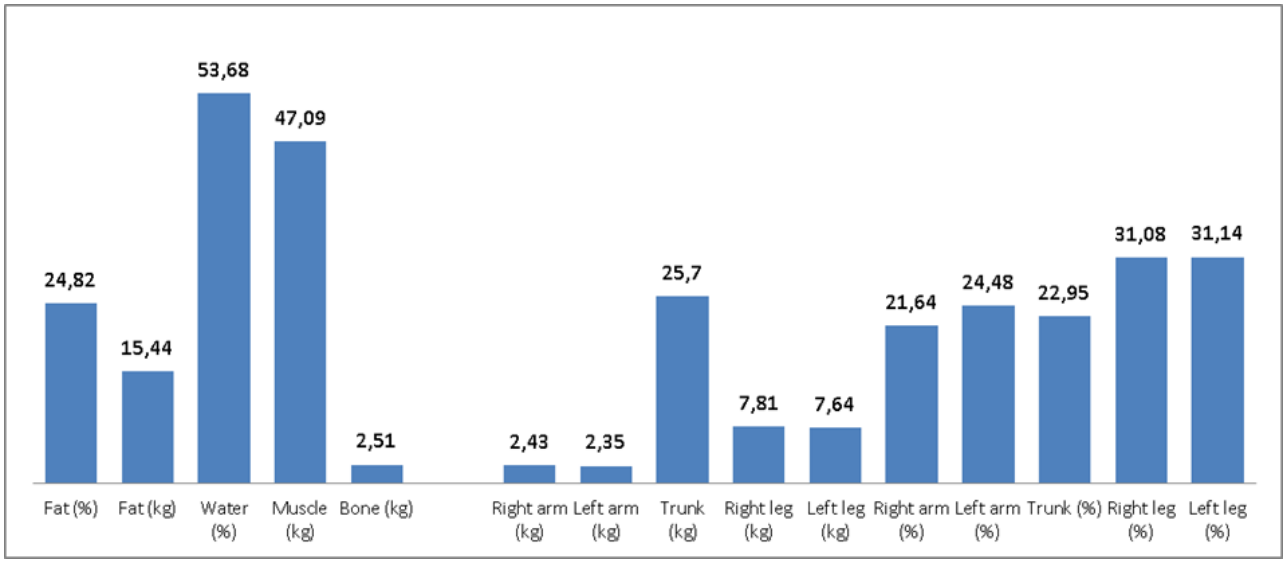

Fig. 1. Body composition

Discussion

It has been scientifically proven that different sports or different competitors in the same sport require different physical characteristics, which reflect body shape, proportions and composition, playing a major role in determining the potential for success, which also applies to volleyball. In addition to adequately developed physical abilities, as well as game efficiency, competitive success in modern volleyball requires an appropriate profile of anthropo-morphological characteristics of players, regardless of gender [40], which defined the goal of this study. The main goal of the current study was to assess and analyze the physical status of volleyball players (VC Jahorina) by analysis of bioelectrical impedance.

In sports, and especially in high-performance sports, continuous monitoring of body composition can regulate the load in the training process by positively influencing top form [22] and technical performance [41]. The authors Baker, & Davies [42] recommend a method of determining the amount of load based on the percentage of fat (free fat mass) instead of the total body weight of the athlete.

Volleyball is a top, versatile team sport, a sport of tactics, strength, speed, coordination, it is played at a faster pace, which means fast thinking, high technical standards and technical application. The game of volleyball can be characterized as an integrated action of skill and strategy. One skill is the ability of the spiker to hit the ball in the desired direction, with explosive power and high speed [43]. It is one of those sports activities in which the anthropometric characteristics and physical status of active participants affect the level of sports performance. Compared to most other athletes, they have characteristic anthropo-morphological characteristics [40] that include body weight, height, girth, skin folds, bone thickness and width, and length [44]. Body composition is largely determined by genetic inheritance [45] and is a common method in sports with a focus on determining the amount of fat component.

The results of this study point to the fact that volleyball players have an average height of 173±8.77 cm, body weight 66.04±9.09 kg, BMI 22.03 kg/m², which is appropriate for volleyball, where there is no obesity. They are slightly lower and easier compared to previous research on a selected sample of Polish, Czech, Portuguese, Brazilian, Greek, and Serbian volleyball players [8, 22, 31, 46-50], but more and heavier than the Indian, Italian, and Japanese sample [7, 9, 51]. Also, the BMI values are within the allowed normal status, which is proportional to the ratio of height and weight of the competitors. Due to the fact that body structure is considered one of the components of physical fitness of athletes, problems related to body composition in sports, especially in volleyball, have been monitored for several years [7, 8, 16, 22, 34]. Numerical parameters of the body status of Jahorina volleyball players (Body fat 24.82%; Body fat 11.44 kg; Body muscle 47.09 kg) are almost identical to the results of a survey of a sample of Indian and Italian clubs [9,

51]. Our sample was more defined by muscle tissue (47.09kg) and partially higher body fat values compared to some previous studies [7, 8, 46, 47, 52]. Also, the results of our sample show a percentage less fat compared to the volleyball players of Greek, Turkish, Brazilian, Polish, Australian and Spanish clubs [4, 6, 27, 31, 48, 53]. In most research to date [7, 8, 25, 53-57] the obtained values of body fat were in the range of 10-25%. The mean values of the current study sample are consistent with previous research, within this wide range. In relation to the distribution of muscle tissue, it can be concluded that the adipose tissue of our sample is within normal limits [6] and will not affect bone loss in bones, technical and physical characteristics of volleyball when performing elements that oppose gravity, which supports the allegations of [11].

Volleyball is an interval team game and belongs to the group of sports disciplines that include indirect fight, so adequate energy coverage of athletes is a key issue [58]. It depends primarily on the type, intensity and duration of physical activity related to the sport discipline that is practiced and the duration of the training cycle [47]. Basal metabolism (BMR) is the number of calories metabolized at rest during 24 hours. The average basal metabolism of Jahorina volleyball players is 1538.08 kCal (1174-1944 kCal), with an average daily consumption of 6435.38 kCal (4912-8134 kCal), which is adequate to the metabolic age of 19.85 years and is slightly higher than their average chronological age. It is the caloric consumption that is the parameter that indicates the importance of the energy needs of the organism that is present in volleyball, which is supported by previous research [25]. In this case, the source of energy is almost always carbohydrates, while the ultimate nature of glycogen transformation (aerobic and anaerobic) is determined by the intensity and duration of physical activity and the degree of fitness of athletes [21]. In addition to body fat and muscle tissue of every athlete, the importance of water in the body is evident, especially in top athletes. During normal conditions or physical activity that lasts a long time, the balance of water and electrolytes in the body are necessary for optimal physiological function and health [34]. The percentage of water in the muscles of our sample is 53.68% (35.20-60.20%) and is a relevant indicator of muscle hydration. Water as a significant ingredient is inversely related to body fat, where any loss of water in muscles leads to a decrease in strength, negatively reflecting on play and outcome [6], as well as homeostasis of body fluids, according to [21] study findings.

Based on the results of the research, it is obvious that the physical status of volleyball players is determined by the average values of adipose tissue and muscle mass characteristic of this population. They are mostly within the allowed values in terms of all parameters (Table 1, Graph 1). Differences are evident in relation to some other competitors from other countries in terms of morphological parameters and physical status and the consequence is different selection, competition rank, training process, biological acceleration, physical fitness, playing position, etc.

Conclusions

This is the first realized study of the assessment of the body composition of VK "Jahorina", a member of the volleyball Premier League of BiH, using the BIA. On the defined sample of a female volleyball players, the results of the study showed that the body composition is within the limits of healthy (allowed) values recommended for this population of volleyball players(Body Fat = 24.82%; Body Fat = 11.44 kg; Body Water = 53.68%; Body muscle = 47.09 kg, BMR = 1538.08, DCI = 6435.38, etc.)

Conflict of interest

The authors declare that there is no conflict of interest.

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