Investigation of exercise intensity in competitive roundnet/spikeball

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Abstract: The game of roundnet (spikeball) is a trend sport that has gained much popularity in leisure time activity in recent years. However, no scientific studies dealing with this trend sport are published yet. The aim of this study was to evaluate the physiological demand of male roundnet players during a roundnet match. Therefore, 12 experienced male roundnet players were recruited. In a pre-experimental test, all participants conducted a ramp-based treadmill test with spirometric measurements. Further, lactate concentrations, velocity and heart rate (HR) were measured. In a subsequent field test, participants conducted a roundnet game in accordance with the official rules. During that field test, the following parameters were measured: Average and maximum HR, lactate concentrations, step count, steps per minute, playing time and rate of perceived exertion (RPE). Results of the pre-experimental test reveal that participants reached a maximum running speed of 5.1±0.2 m/s, a maximum HR of 190.4±7.2 bpm and a VO_{2max} of 55.8±4.2 ml/min/kg. Results of the field test showed that participants reached a maximum HR of 159.7±7.9 bpm corresponding to 83.9±3.6% of the participant's maximum HR. Average HR was 133.6±9.4 bpm corresponding to 70.1±4.2% of the participant's maximum HR. Participants reached a mean lactate concentration of 1.2±0.2 mmol/l and a RPE score of 13.2±1.2. The mean playing time of one set was 10.8±0.8 minutes. On average, 790.5±125.2 steps were measured during one set equaling 73.1±11.6 steps per minute. To conclude, this study first time presents game characteristics and the physiological demand of the trend sport roundnet. Results indicate that the physiological demand can be described as moderate as none of the measured parameters reaches disproportionately high values.

Key Words: Spikeball, heart rate, rate of perceived exertion, speed

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1. Introduction

The game of roundnet (spikeball) is a trend sport that has gained much popularity in leisure time activity in recent years. Besides, the popularity of roundnet is continuing to grow as tournaments and leagues are beginning to develop in larger scales, e.g. the Spikeball Roundnet Nationals, which were held in Santa Monica, California with more than 400 participating athletes. Roundnet is a team sport played by two teams consisting of two players. Opposing teams line up across from each other with the roundnet net in the center. The ball is put in play with a service—a hit by the server from behind the

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service boundary into the net to an opposing player. Once the ball is served players can move anywhere they want. The objective of the game is to hit the ball into the net so that the opposing team cannot return it and the ball hits the ground. Three touches are allowed within the team return the ball. The rally continues until the ball is not returned properly [1].

However, the physiological demands of roundnet are very poorly understood as no research has been conducted in this area. Consequently, training methods remain diverse. The aim of this study was to measure physiological variables during play und to provide a unique profile which can better identify the overall intensity and physiologic stress of roundnet.

2. Materials and Methods

2.1 Participants

The study was designed to evaluate the physiological demand of male roundnet players during a roundnet match. The study was conducted at the German Sports University Cologne and all participants gave informed written consent. The used protocols in this study were approved by the ethics committee of the German Sport University Cologne. These protocols align with the Declaration of Helsinki of 1964. Twelve participants were recruited by a local roundnet club. All participants compete regularly in national and international tournaments. Participants were included, if they were healthy, 170 to 190 cm tall, 65 to 100 kg heavy, and 18 to 35 years old. Further, participants needed to train at least two times a week for roundnet. Exclusion criteria were nicotine-, alcohol- , or drug abuse. Cardiovascular diseases, diabetes mellitus, oncological or hematological pre-existing condition, acute infections, uncontrolled asthma, and insufficiently controlled epilepsy resulted in exclusion. Anthropometric data were measured prior to the pre-experimental test and are presented in Table 1. Further, subjects filled out a questionnaire. Consumption of alcohol was prohibited 48 hours before the test, high-carbohydrate drinks were prohibited at the same day. Participants were asked to avoid high-intensity training 48 hours before

testing.

2.2 Pre-experimental test

All participants completed a ramp based treadmill (Woodway, Woodway-Geres GmbH, Lörrach) test until exhaustion as done before [2] [3]. Using this test, the individual maximal heart rate (HR_{max}) and the maximum blood lactate (LA_{max}) concentration was measured. Besides, spirometry data were measured during the test and VO_{2max} values were recorded. The 15 point RPE-scale was further used to estimate subjective exhaustion. The results of HR_{max}, LA_{max} and VO_{2max}, as well as the anthropometric data are presented in Table 1. Spirometry data were measured using the mobile system MetaMax 3B (Cortex Biophysik GmbH, Leipzig, Germany) and analyzed with the MetaSoft Studio software. Sensors were calibrated unsing the calibration syringe 3000 ml (Cortex Biophysik GmbH, Leipzig). Heart rate was measured via heart rate monitors (Polar FT1, Polar Electro OY, Kempele, Finland). To examine total exhaustion the following four criteria were used: reaching $\geq 100\%$ of the calculated HR_{max}, LA_{max} >8mmol/l, ventilatory equivalent (EQO_2) >30, and the maximum respiratory quotient (RQ_{max}) over 1,1.

2.3 Field testing

All field tests were conducted in secluded and quiet area in a gymnasium. Each participant played three sets to 21 points in accordance to the official roundnet rules. The pause between the sets was set to three minutes. Only participants of this study were allowed to play. A standardized warm-up was completed by every participant. The warm-up included two minutes of jogging, 150 m of walking with mobilization and passing and three min of playing roundnet at a submaximal intensity. Heart rate monitors and pedometers (REFLECTS GmbH, Cologne, Germany) were applied to each participant after the warm-up. During the field test, Lactate concentrations [mmol/L] (LA_{field}) were measured before (t0) and after the each of the three sets played, respectively (t1, t2, t3). Maximum HR [1/min] ($HR_{max-field}$), average HR [1/min] ($HR_{avg-field}$),

step count, steps/minute [1/min] and RPE-score were measure at t1, t2, and t3, respectively. Moreover, the playing time (min) per set was recorded.

2.4 Statistical analysIs

Statistical analyses were performed using the software SPSS 25 (IBM). Data are presented as the mean ± standard deviation. Differences were considered as significant with $p < 0.05$. The Kolmogorov-Smirnov-test was used to check for standard distribution. To calculate the differences between the played sets, a one-factor analysis of variance for repeated measures and a Friedmann-test were conducted.

Table 1. Anthropometric, training and performance data of participants. Performance data were measured during the pre-experimental test. Data are presented as means ± standard deviation. VO_{2max}= maximal oxygen uptake capacity; LA_{max} = maximal lactate concentration; HR_{max} = maximal heart rate.

Men/women	12/0
Age [years]	25.8±3.2
Height [m]	184±6.1
Weight [kg]	81.8±8.2
Body Mass Index [kg/m²]	24.0±1.1
Regular training (session/week)	4.7±0.9
Specific roundnet training (session/week)	2.3±1.3
Experience in roundnet [years]	1.7±0.4
Max. velocity of pre-experimental test [m/s]	5.1±0.2
VO_{2max} [ml/kg/min]	55.8±4.2
LA_{max} [mmol/l]	10.0±1.6
HR_{max} [1/min]	190.4±7.2
Max. rate of perceived exertion	18.2±1.3

Two independent samples are examined for their central tendency using the Mann-Whitney-U test. The exact double significance was calculated. A paired t-test was used to evaluate the differences between two paired samples.

3. Results

All participants fulfilled at least three of four criteria of exertion on the treadmill test. In the pre-experimental test, participants reached a maximum running speed of 5.1±0.2 m/s, a HR_{max} of 190.4±7.2 bpm and a VO_{2max} of 55.8±4.2 ml/min/kg (Table 1).

During the entire roundnet game (data of all sets are included), participants reached a mean $HR_{max\text{-}field}$ of 159.7±7.9 bpm corresponding to 83.9±3.6% of the participant's HR_{max}. Measured $HR_{max\text{-}field}$ values for each time point were as follows: t1: 156.0±11.7, t2: 161.7±10.2, t3: 161.3±8.9. During the entire roundnet game, the mean $HR_{avg\text{-}field}$ was 133.6±9.4 bpm corresponding to 70.1±4.2% of the HR_{max}. Measured $HR_{avg\text{-}field}$ values for each time point were as follows: t1: 131.3±10.8, t2: 132.9±11.0, t3: 136.4±9.0. Both, $HR_{max\text{-}field}$ and $HR_{avg\text{-}field}$ did not increase significantly within the match and no significant difference was observed in any of these parameters between t1, t2, and t3 ($p > 0.05$; Figure 1).
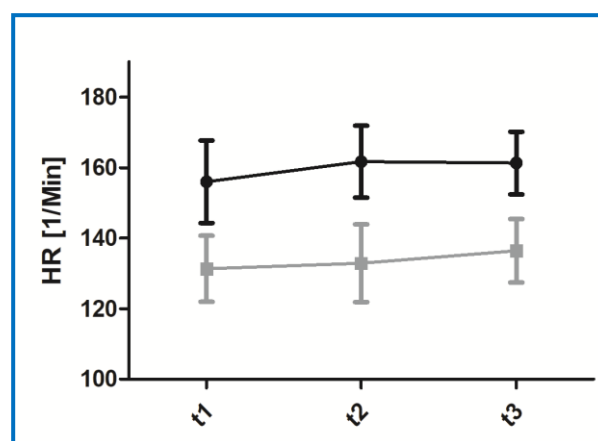

Figure 1. Measured heart rate (HR) during the field test. Grey color indicates maximum heart rate measured during the respective set. Black color indicates average heart rate throughout the respective set. Data are presented as means ±standard deviation. No significant difference is observed.

During the entire roundnet game, participants reached a mean LA_{field} of 1.2±0.2 mmol/l. Measured LA_{field} values for each time point were as follows: t0: 0.98±0.13, t1: 1.20±0.39, t2: 1.19±0.5, t3: 1.15±0.33. No significant differences were observed between the four time points (t0, t1, t2, and t3) in the parameter LA_{field} (p>0.05; Figure 2).

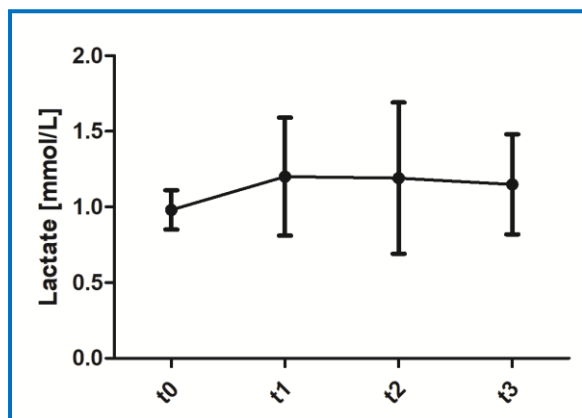**Figure 2.** Measured lactate concentrations during the field test. Data are presented as means ±standard deviation. No significant difference is observed.

Further, the mean RPE score during the entire roundnet game was 13.2±1.2. Measured RPE scores values for each time point were as follows: t1: 12.8±1.3, t2: 13.3±1.4, t3: 13.5±1.9. The RPE showed no significant differences between the four time points (p>0.05; Figure 3).
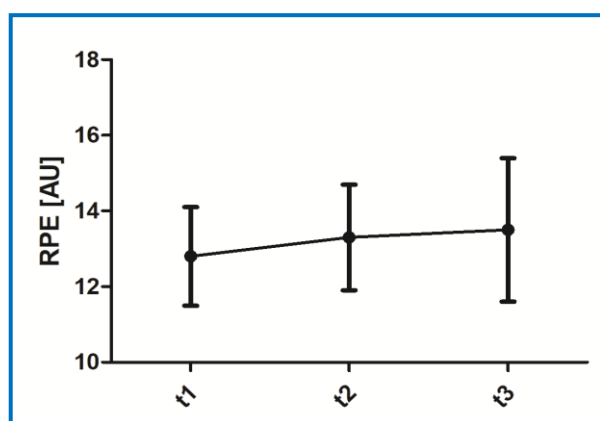

Figure 3. Rate of perceived exertion (RPE) score measured during the field test. Data are presented as means ±standard deviation. No significant difference is observed.

The mean playing time of all sets was 10.8±0.8 minutes. The playing time of each set was as follows: t1: 11.7±2.2 min, t2: 9.5±0.7 min, t3: 11.2±1.8 min. Playing time of set two was significantly lower compared to set one (p=0.024;
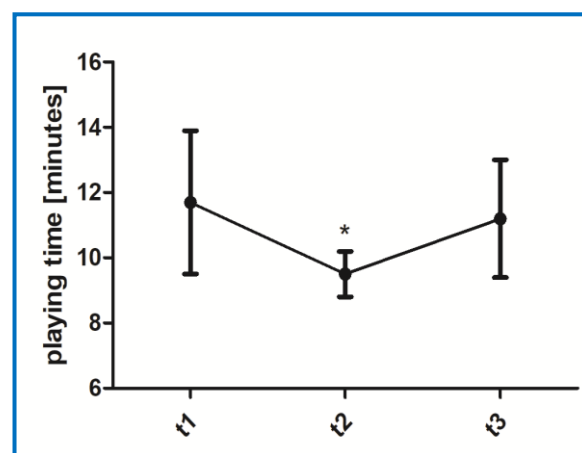
Figure 4).

Figure 4. Measured playing time per set during the field test. Data are presented as means ±standard deviation. * Significantly lower value compared to t1 and t3.
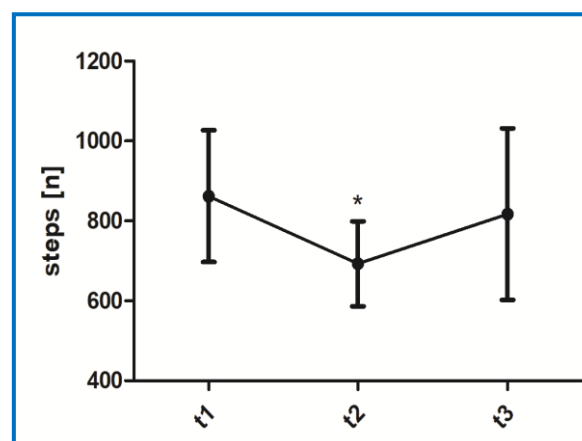

Figure 5. Measured steps per set during the field test. Data are presented as means ±standard deviation. * Significantly lower value compared to t1 and t3.
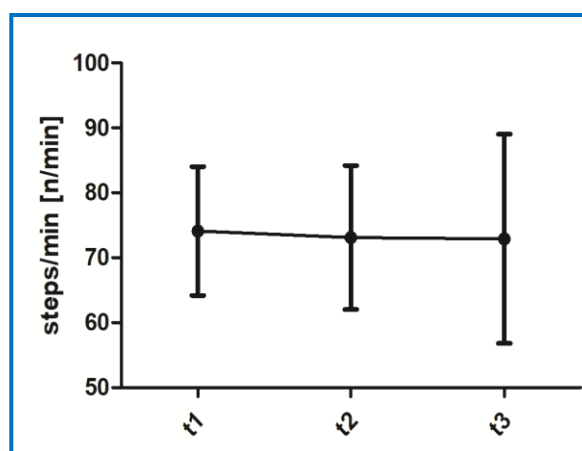

Figure 6. Measured steps per minute during the field test. Data are presented as means ±standard deviation. No significant difference is observed.

On average, 790.5±125.2 steps were measured during one set equaling 73.1±11.6 steps per minute. The numbers of steps per set were as follows: t1: 861.9±165.0, t2: 692.7±106.2, t3: 817.0±214.6. In set two, the number of steps was significantly lower compared to set one (p=0.003, Figure 5). Steps per minute measured every set were as follows: t1: 74.1±9.9, t2: 73.1±11.1, t3: 72.9±16.1. No significant difference between the sets was observed in steps per minute (p>0.05; Figure 6).

4. Discussion

To the best of our knowledge, this is the first study investigating the physiological demand of the trend sport roundnet. The results of the present study first time provide a profile of heart rate, lactate concentration, and step count responses during a competitive roundnet field test. Previous studies have examined the physiological profile of other court-return sports such as tennis [4], badminton [5] and squash [6] but no literature is available for the roundnet.

Results indicate that the VO_{2max} measured during the pre-experimental treadmill test was similar compared to values reported in other studies dealing with court-return sports. In the present study, the mean VO_{2max} was 55.8±4.2 ml/min/kg and ranged from 48 to 62 ml/min/kg. In tennis, VO_{2max} values of 58,5±9,4 ml/min/kg are reported [4]. VO_{2max} values of squash players are reported with a mean value of 58.8±2.9 ml/min/kg [6] which are thus slightly higher compared to the VO_{2max} values of the present study. Badminton players showed VO_{2max} values of 55.7±4.,4 ml/min/kg [7].

The present study shows that $HR_{avg\text{-}field}$ in roundnet (133.6±9.4 bpm) is in a moderate range, which equals the match intensity of tennis with a mean HR of 144.6±13.2 bpm measured during a tennis match [4]. The average in-match HR are higher in badminton with values reported of 173.4±8.9 bpm [5] and 157.0±11.0 bpm [7]. Literature on in-game measurement of HR in squash reveal mean values of 163±5 bpm in similar aged men showing a higher intensity in squash [6].

In the present study the match intensity is observed to equal 83.9±3.6% of the participants HR_{max}. The match intensity of other court-return sports is very similar as in badminton the intensity equals 75-90%, in tennis 60-70%, and in squash 80-90% of the participant's HR_{max} [8].

Both, the blood lactate concentrations measured before the pre-experimental test and before the field test were lower than 1 mmol/l with values of 0.90±0.25 mmol/l and 0.98±0.18 mmol/l, respectively. Therefore, baseline blood lactate concentrations indicate that no intensive exercise was conducted the tests that might have influenced the participant's performance. During field test, the mean value of LA_{field} was 1.2±0.2 mmol/l, which indicates a very moderate intensity. This low value is in line with the very moderate HR valued measured during the field test. Both results indicate that the game of roundnet possesses a moderate game intensity. In tennis blood lactate concentrations of 2.0±0.4 mmol/l [6] and 3.8±2.0 mmol/l [9] are reported. In Badminton, blood lactate concentrations of 4.7±1.9 mmol/l are reported [7]. In squash, blood lactate concentrations of 8-9 mmol/l are reported [10].

The comparison of the LA_{field} values of the present study with values of studies conducted in other court-return sports indicates that the in-match intensity of roundnet seems to be much lower than the intensity of the above mentioned sport types. The measured lactate values most likely indicate a mainly aerobic load with short anaerobic-alactic peaks during the match. The measured consistent RPE values of 13.2±1.2 support the above mention low intensity of roundnet. This value is comparable with the reported RPE score of squash players, who report a RPE score of 12.1±1.3 [10].

In the present study the duration of one set was 10.8±0.8 minutes. Hence, the duration of a competitive match is expected to be 22 or 33 minutes depending on the number of sets played as the regular game mode is a best-of-three mode. In other court-return sports the mean duration of a match lays between 20 to 90 minutes [11] or 30 to 90 minutes [10]. Therefore, the duration of a game of roundnet is much shorter compared to other court-return sports.

No comparisons can be made with the number of steps, as there are no data to compare it to. However, the number of steps is in line with the short duration of the game length and supports the assumption that the game intensity of roundnet can be described as moderate.

On average, the second set was significantly shorter compared to the first and third set. The number of steps was therefore also lower in the second set compared to the first and third one. The reasons for that remain elusive and cannot be explained.

5. Conclusion

The exercise intensity of roundnet can be considered as moderate and constant during a match of roundnet. Compared to other court-return sports, like badminton, tennis, and squash the sport roundnet shows lower in-match intensity as HR and lactate concentration values, as well as RPE scores and step numbers are in moderate ranges. Therefore, no increased cardiovascular risk can be determined from the conducted measurements. Further investigations should include further parameters such as blood pressure as well as a spirometric examination into future study designs to provide further information on the exercise intensity, the cardiovascular load and the general understanding of this trend sport.

References

[1] USA Spikeball. USA Spikeball. http://usaspikeball.com/ (2019).

[2] F. Tomschi, D. A. Bizjak, H. G. Predel, W. Bloch, M. Grau, Lactate distribution in red blood cells and plasma after a high intensity running exercise in aerobically trained and untrained subjects, *Journal of Human Sport and Exercise*, 13 (2018) 384-392.

[3] F. Tomschi, H. Ottmann, J. Latsch, H. G. Predel, W. Bloch, M. Grau, Does the acute hemodynamic response to a maximum running exercise depend on the aerobic training status of the subjects?, *Artery Research*, 23 (2018) 28–31.

[4] M. F. Bergeron, C. M. Maresh, W. J. Kraemer, A. Abraham, B. Conroy, C. Gabaree, Tennis: a physiological profile during match play, *International Journal of Sports Medicine*, 12 (1991) 474–479.

[5] D. Cabello Manrique, J. J. González-Badillo, Analysis of the characteristics of competitive badminton, *British Journal of Sports Medicine*, 37 (2003) 62–66.

[6] O. Girard, R. Chevalier, M. Habrard, P. Sciberras, P. Hot, G. P. Millet, Game analysis and energy requirements of elite squash, *The Journal of Strength and Conditioning Research*, 21 (2007) 909–914.

[7] P. Majumdar, G. L. Khanna, V. Malik, S. Sachdeva, M. Arif, M. Mandal, Physiological analysis to quantify training load in badminton, *British Journal of Sports Medicine*, 31 (1997) 342–345.

[8] T. McGarry, Peter O. DonoGhue, (2013) Jaime Sampaio, Routledge handbook of sports performance analysis, *Taylor & Francis*, New York.

[9] A. Mendez-Villanueva, J. Fernandez-Fernandez, D. Bishop, B. Fernandez-Garcia, N. Terrados, Activity patterns, blood lactate concentrations and ratings of perceived exertion during a professional singles tennis tournament, *British Journal of Sports Medicine*, 41 (2007) 296-300.

[10] T. Reilly, D. L. Halsall, (1995) Physiological effects of squash participation in different age-groups and levels of play, In: Reilly T, Hughes, M., Lees, A. (eds), Science and Racket Sports, *Taylor & Francis*, London, New York, 44–50.

[11] A. Lees, Science and the major racket sports: a review, Journal of Sports Sciences, 21 (2003) 707–732.

Acknowledgements

Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflicts of interest.

Ethical approval

The used protocols in this study were approved by the ethics committee of the German Sport University Cologne. These protocols align with the Declaration of Helsinki of 1964.

Informed consent

All participants gave written informed consent to participate in this study.

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