Journal of Human Sport and Exercise
E-ISSN: 1988-5202
jhse@ua.es
Universidad de Alicante
España

VENCÚRIK, TOMÁŠ; NYKODÝM, JIRÍ; STRUHÁR, IVAN
Heart rate response to game load of U19 female basketball players
Journal of Human Sport and Exercise, vol. 10, núm. 1, 2015, pp. S410-S417
Universidad de Alicante
Alicante, España

Proceeding

9th INSHS International Christmas Sport Scientific Conference, 4-6 December 2014. International Network of Sport and Health Science. Szombathely, Hungary

Heart rate response to game load of U19 female basketball players

TOMÁŠ VENCÚRIK ✉ , JIŘÍ NYKODÝM, IVAN STRUHÁR

Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

ABSTRACT

Vencúrik, T., Nykodým, J., & Struhár, I. (2015). Heart Rate Response to Game Load of U19 Female Basketball Players. *J. Hum. Sport Exerc., 9*(Proc1), pp.S410-S417. The aim of the study is to compare the intensity of game load between player positions (guards, forwards, centers) and between the 1st and the 2nd half of the basketball games in female category U19. Ten female basketball players (17.6 ± 0.9 years old) participated in this study. The beep test was used to determine the maximal heart rate (HRmax) and based on the HRmax the four intensity zones were set (< 75%, 75-84%, 85-95%, > 95% of HRmax). The heart rate (HR) and its development during the competition were monitored by telemetric device Suunto Team Pack. We did not record any statistical significance among player positions in particular intensity zones, nor in % of HRmax (86 ± 2.8 vs. 88.3 ± 2.9 vs. 87.7 ± 3.3; guards vs. forwards vs. centers). Moreover, when we compared the 1st and the 2nd half, of individual games, in particular zones and in % of HRmax (87.8 ± 3 vs. 86.8 ± 3.1) we also did not record any statistical significance. The female basketball players spent 74.3% of total time with HR greater than 85% of HRmax which indicates high physiological demands during the competition on all player positions. The results can be used for comparison with the intensity of training load and for optimizing the training process. **Key words**: INTENSITY OF LOAD, PLAYER POSITIONS, MAXIMAL HEART RATE

✉ **Corresponding author.** Faculty of Sports Studies, Masaryk University, Brno, Czech Republic
E-mail: vencurik@mail.muni.cz
9th INSHS International Christmas Sport Scientific Conference, 4-6 December 2014. International Network of Sport and Health Science. Szombathely, Hungary.
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202

doi:10.14198/jhse.2015.10.Proc1.33

INTRODUCTION

Basketball comprises of specific structural and functional characteristics which singularize basketball from other team sports (Trninić et al., 2010). Therefore, the concept of training should be based on the real game conditions so the individual and team game performance could increase. According to Hoffman (2002), from the training process' point of view it is important to be aware of the physical and physiological demands which are the players exposed to during games. Based on this knowledge it is possible to form adequate training program and thus increase the efficiency of the training process.

The games' physical demands are gained by the time-motion analysis (McInnes et al., 1995; Abdelkrim et al., 2007; Erčulj et al., 2008; Montgomery et al., 2010; Scanlan et al., 2011). In the basketball game are interchanging irregular time sections in which are executed moves in different intensities of load (stand, walk, runs in various intensities, specific shuffle-motion in various intensities and jumps). Abdelkrim et al. (2007) state the mean frequency for all activities 1050 ± 51 movements in the U19 category (male basketball players) while the players performed 55 ± 11 (approximately every 39 seconds) sprints in high intensity during the game. Matthew & Delextrat (2009) recorded in average 652 ± 128 movements and 49 ± 17 short sprints in the game of female basketball players. These studies point out the intermittent character of the load in basketball, while the energy for physical activity is supplied by both aerobic and anaerobic processes.

As an objective and noninvasive physiological indicator of the intensity of load is the heart rate (HR) used most frequently, it can be monitored repeatedly and without any major financial expenses (Achten & Jeukendrup, 2003; Pettitt et al., 2007; Gocentas et al., 2011; Kenney et al., 2012). Numerous studies have been interested in determining the physiological demands in competitive (McInnes et al., 1995; Rodríguez-Alonso et al., 2003; Tessitore et al., 2006; Abdelkrim et al., 2007; Matthew & Delextrat, 2009; Abdelkrim et al., 2010; Scanlan et al., 2012), and also pre-season or practice games (Vaquera et al., 2008; Narazaki et al., 2009; Hůlka et al., 2013). McInnes et al. (1995) state that the elite players played approximately 75% of the total time with the HR greater than 85% of maximal heart rate (HRmax). Abdelkrim et al. (2010) noticed, after the change of rules in 2000, similar percentage of played time in zone > 85% of HRmax (75.3% of the total time) in the U19 category (male basketball players). Matthew & Delextrat (2009) specified the physiological demands in the senior female category, while the players played 80.4% of the total time and above the 85% level of HRmax. Rodríguez-Alonso et al. (2003) and Abdelkrim et al. (2007) present statistically significant differences in absolute values of HR (beats·min^{-1}) between guards and forwards, and also between guards and centers in the senior category (female basketball players) and U19 (male basketball players), respectively. The differences in mean HR represented a % of HRmax between the guards and forwards, and also guards and centers are introduced by Vaquera et al. (2008).

The aim of this study is to determine whether there are any differences in the intensity of load of individual player positions (guard, forward, and center) and between the 1st and the 2nd half in the competitive games of the female U19 basketball.

MATERIAL AND METHODS

Participants

Ten female basketball players who played the 1st division in U19 participated in this study (3 guards, 3 forwards, and 4 centers). The average age of the basketball players was 17.6 ± 0.9, average body weight was 62.9 ± 5 kg, and body height was 179.5 ± 5.9 cm. In one week (7 days) the players completed: 4

training sessions on court (90 min. each), 2 shooting practice sessions (60 min. each), 1 active recovery (1 hour in swimming pool), and 2 competitive games.

Procedure

To respect the individual distinctiveness of the tested female basketball players are all values of the heart rate presented in relative values (according to the % of HRmax) (Ziv & Lidor, 2009). The HRmax of all players was set on the basis of the 20 m shuttle run test (Léger et al., 1988) which was also used in studies: Abdelkrim et al. (2010), Scanlan et al. (2012), Hůlka et al. (2013), and others. Monitoring of HR was conducted during 2 competitive games of 1st division female U19 category. The games were played in compliance with the FIBA rules and 2 referees were officiating the game. The court had standard dimensions (28 m long and 15 m wide). Each quarter was 10 min. (live time) long. Between the 1st and the 2nd, and the 3rd and 4th quarter was a 2 min. long break. Between the 2nd and the 3rd quarter was half-time break in duration of 15 minutes. The games were recorded on video camera Canon HG10 (Canon Inc.,Tokyo, Japan) for the purpose of subsequent detailed video-analysis (substitutions, breaks between quarters, etc.).

Heart Rate

The HR was during the games monitored with the use of commercially accessible telemetric system Suunto Team Pack (Suunto Oy, Vantaa, Finland). Suunto memory belts were set to monitor the HR in 2-seconds intervals and were synchronized with the game time. The HR values were recorded to laptop and also subsequently downloaded from the internal memory of the belts to the laptop, in case of possible signal failure. The acquired data was then processed in respective software program Suunto Training Manager. Only data acquired during the total time were interpreted (Ziv & Lidor, 2009). The total time was defined according to Matthew & Delextrat (2009) as the time during which the players were on the court, including the short interruptions in game, free-throw shooting, and time-outs. In total game time is not included the time spent on the bench and the breaks between the individual quarters. The intensity of load was, based on the % of HRmax, classified into 4 zones (Abdelkrim et al., 2010a; Deutsch et al., 1998): 1. Low (<75% of HRmax), 2. Moderate (75-84% of HRmax), 3. High (85-95% of HRmax), 4. Maximal (>95% of HRmax). Moreover, the mean HR reached during the total time is expressed in % of HRmax.

Statistical Analysis

The descriptive statistics and the data represented as mean ± standard deviation are used. The time played in the 1st and the 4th zone was too short for statistical comparison between the player positions and also between the two halves. Because of this, the comparison >85% of HRmax (3rd and 4th zone combined) was included. The data normality was verified by the Shapiro-Wilk test and the homogeneity by the Leven's test. The data was not transformed and we worked with initially gained values. To compare the differences between the player positions (guard, forward, center) in the 2nd zone and in zone >85% of HRmax the nonparametric Kruskal-Wallis test was used, and in the 3rd zone and in mean HR (as % of HRmax) was the one-way ANOVA analysis employed. To compare the difference between the game halves in the 2nd zone and in zone >85% of HRmax the nonparametric Mann-Whitney U-test was used, and in the 3rd zone and in the mean HR (as % of HRmax) was the parametric t-test used. To statistically process the data the software Statistica 12 (StatSoft, Inc., Tulsa, USA) was used. The tests were assessed on level of statistical significance α = 0.05. The results were supplemented with the effect size calculation. To compare the game halves the Cohen's d coefficient was used, for Kruskal-Wallis test was $\eta 2$ coefficient used, and for ANOVA the $\omega 2$ coefficient was used (Ellis, 2010; Thomas et al., 2011).

RESULTS AND DISCUSSION

The guards played in the 2nd a in the 3rd zone in average 20.6 ± 14.8% and 69 ± 17.4% of total time, respectively. In zone >85% of HRmax they played 70.9 ± 17.9% of total game time and the mean HR was on the level 86 ± 2.8% of HRmax. The forwards played in the 2nd zone 16.3 ± 7.8%, in the 3rd zone 68.8 ± 11.8%, and in the zone >85% of HRmax 77.2 ± 11.4% of the total time. The mean HR reached the value 88.3 ± 2.9% of HRmax. The centers played in the 2nd zone, the 3rd zone, and in the zone >85% of HRmax 17.6 ± 11%, 64.9 ± 13.3%, and 74.7 ± 14.5% of the total game time, respectively. The value of the mean HR was similar to the one of the guards and forwards': 87.7 ± 3.3% of HRmax. On the basis of the Kruskal-Wallis test no statistically significant differences ($p > 0.05$) were detected between the player positions in the 2nd zone and in the zone >85% of HRmax. It is a small effect between the player positions in the 2nd zone ($\eta^2 = 0.005$) and in the zone >85% of HRmax ($\eta^2 = 0.017$) from the practical significance's point of view. In the 3rd zone and in the zone >85% of HRmax ANOVA did not detect any statistically significant differences (p > 0.05). The practical significance coefficient pointed out the small effect in the differences between the player positions in the 3rd zone (ω^2 = - 0,021) and in the % of HRmax (ω^2 = 0,051) (Tab. 1), as well.

Rodríguez-Alonso et al. (2003) notice the differences in the absolute values of HR (in beats·min^{-1}) between the guards and forwards and between the guards and centers, as well. In the U19 category of male basketball players Abdelkrim et al. (2007) notice similar results in the absolute values of HR. These studies compare the absolute values of HR and thus did not respect the individual distinctiveness of the players. Vaquera et al. (2008) present the differences between the guards and forwards, and the guards and centers in % of HRmax in the senior category of male basketball players. Scanlan et al. (2012) noticed the differences in % of HRmax between the players performing in the frontcourt (point guards and shooting guards) and the players performing in the backcourt (small forwards, power forwards, and centers) in senior category of female basketball players.

Table 1. The Differences among Player Positions in the Individual Zones of the Intensity of Load and in the Mean HR as % of HRmax

Physiological demand	Player position			Statistical significance	Practical significance
	guard	forward	center		
75 – 84%	20.6 ± 14.8	16.3 ± 7.8	17.6 ± 11	$p > 0.05$	$\eta^2 = 0.005$
85 – 95%	69 ± 17.4	68.8 ± 11.8	64.9 ± 13.3	$p > 0.05$	$\omega^2 = - 0.021$
> 85%	70.9 ± 17.9	77.2 ± 11.4	74.7 ± 14.5	$p > 0.05$	$\eta^2 = 0.017$
HR as % of HRmax	86 ± 2.8	88.3 ± 2.9	87.7 ± 3.3	$p > 0.05$	$\omega^2 = 0.051$

When the 1st and 2nd half were compared no statistically significant differences (p > 0,05) were determined in the 2nd zone (16.1 ± 10.8 vs. 20.4 ± 11.4%), the 3rd zone (66.6 ± 14.2 vs. 68,1 ± 13.6%), in the zone >85% of HRmax (76.3 ± 13.5 vs. 71.9 ± 15.4%), and not even in the mean HR expressed as % of HRmax (87.8 ± 3 vs. 86.8 ± 3.1%). The calculated Cohen's d coefficient points out, when the 1st and the 2nd half are compared, a small effect of practical significance in the 2nd (*d* = 0.393), in the 3rd (*d* = 0.111), in the zone > 85 % (*d* = 0.299), and also in % z HRmax (*d* = 0.351). From the results can be concluded that between the 1st and the 2nd half is not neither statistically nor practically significant difference, even if higher values of HR were reached in the 1st half (Tab. 2). These values are comparable to Rodríguez-Alonso et al. (2003), who also did not record and difference between the two game halves in the mean HR expressed in % of HRmax. However, Matthew & Delextrat (2009) noticed the differences between the two game halves, while the higher HR was recorded in the 1st half. This difference could be caused by more frequent interruptions in the final quarters of the game, especially in tight/dramatic games (i.e. time-outs, more frequent free-throw shooting).

Table 2. The Differences between 1st and 2nd half in the Individual Zones of the Intensity of Load and in the Mean HR as % of HRmax

Physiological demand	1st half.	2nd half	Statistical significance	Practical significance
75 – 84%	16.1 ± 10.8	20.4 ± 11.4	$p > 0.05$	$d = 0.393$
85 – 95%	66.6 ± 14.2	68.1 ± 13.6	$p > 0.05$	$d = 0.111$
> 85%	76.3 ± 13.5	71.9 ± 15.4	$p > 0.05$	$d = 0.299$
HR as % of HRmax	87.8 ± 3	86.8 ± 3.1	$p > 0.05$	$d = 0.351$

The female basketball players, with taking the player position into consideration, played in average 7.6%, 18.1%, 67.3%, and 7% of the total time in the 1st, 2nd, 3rd, and 4th zone of intensity of load, respectively (Fig. 1). Above the 85% of HRmax it was 74.3% of the total time. The ratio of the total time below and above the 85% of HRmax was 25.7:74.3, what corresponds to the ratio 1:2.9. Matthew & Delextrat (2009), in senior female category, and Abdelkrim et al. (2010), in male U19 category, state similar 80.4% and 75,3% proportion of the total game time above 85% of HRmax. However, Hůlka et al. (2013) determined lower proportion (63.11%) above the 85% of HRmax in male U18 category, which is explained by the lower performance standard. This lower percentage proportion could be also caused by the fact that the game was only "warm-up" game and therefore the players' motivation and determination could be on lower level.

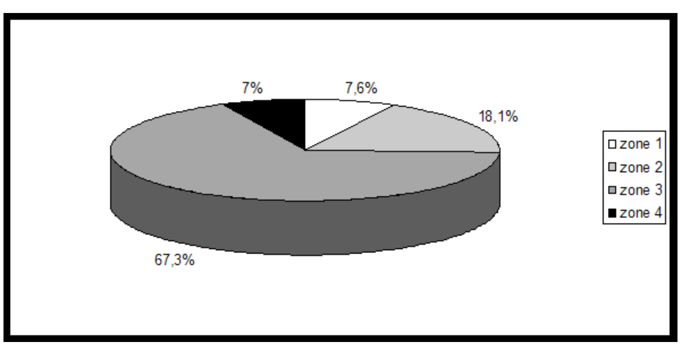

Figure 1. Mean of the relative time spent in the individual zones of the intensity of load

The mean HR of the total time, of the female basketball players, was at the level 87.4 ± 3.1% of HRmax. This value corresponds to the values in researches by Rodríguez-Alonso et al. (2003) (90.8% and 94.6% of

HRmax in female national and international basketball league) and Metthew & Delextrat (2009) (89.1% of HRmax in the highest female national league in England). Scanlan et al. (2012) state the mean HR as 68.6% of HRmax of the total time in the regional female competition. The different mean values of HR expressed in % of HRmax were also determined by Hůlka et al. (2013) (85.06% of HRmax in male U18 category) and Abdelkrim et al. (2007) (91% of HRmax in male U19 category). It can be concluded that the difference of physiological demands of a basketball game can depend on the sex, age category, chosen tactics (Hoffman, 2003), performance and conditioning level (Krustrup et al., 2005) of the monitored male and female basketball players. The HR is an indicator which may be affected not only by the intensity of load but also other factors as emotional stress and mental strain. According to Bangsbo (1994) the impact of the psychological factors on the HR is lower in the high-intensity physical activity, and high-intensity is characteristic for a basketball game.

These results may be an apt indicator for the objectification of the training process and for the opportunity to compare the estimated and real physical load. Therefore, we see the monitoring of the HR useful also for the training process – aiming at the long-term observation which should help prevent overstrain and overtraining of the monitored players. The results may also serve as a base for the creation of training programs, either of game or conditioning character.

Expressing the load only on the basis of the internal response of the organism does not need to be sufficient, however, we do not think that this would lead to the misinterpretation of the results. If we used also the time-motion analysis, and not only the internal parameters, as it was done in studies like Abdelkrim et al. (2007), Hůlka et al. (2013), Klusemann et al. (2013), Matthew & Delextrat (2009), McInnes et al. (1995), Scanlan et al. (2012), and Tessitore et al. (2006), we could reach a complex view on the evaluation of the load.

CONCLUSIONS

This study compares physiological demands of a basketball game between the individual player positions and also looked at from the standpoint of the progress of the game, the differences between the two game halves. The results indicate high physiological demand on the monitored female basketball players during the games, however, without any significant and practically significant differences between the player positions and between the two game halves. Information of this character may be useful for preparation, leading of a training process, creation of training programs either of game or conditioning character. The training process should take into account the ratio of the time played below and above 85% of HRmax (approx. 1:3), and the intensity of load should have an intermittent character. The greatest contribution in the monitoring of the HR in the real game conditions is in the comparison of the intensity of the game and training load and in the possibility to adjust it. The combination of monitoring the internal (HR) and external (time-motion analysis) parameters would offer more complex view of the area of the load evaluation in the basketball game.

If the number of research subjects and number of measuring was higher we could have reached more detailed results and more concrete recommendations for the training process. These results should also be verified against other age categories, categories of different performance level, and sex, furthermore, this should allow to draw generally valid conclusions.

ACKNOWLEDGEMENTS

This study was funded by the project Specific Research at Masaryk University (MUNI/A/0900/2013).

REFERENCES

1. Abdelkrim, N.B., Castagna, C., Jabri, I., Battikh, T., Fazaa, S.E., & Ati, J.E. (2010). Activity profile and physiological requirements of junior elite basketball players in relation to aerobic-anaerobic fitness. *Journal of Strength and Conditioning Research*, *24*(9), pp.2330-2342.
2. Abdelkrim, N.B., Fazaa, S.E., & Ati, J.E. (2007). Time-motion analysis and physiological data of elite under-19-year-old basketball players during competition. *British Journal of Sports Medicine, 41*(2), pp.69-75.
3. Achten, J., & Jeukendrup, A.E. (2003). Heart Rate Monitoring: Applications and Limitations. *Sports Medicine, 33*(7), pp.517-538.
4. Bangsbo, J. (1994). Energy demands in competitive soccer. Journal of Sports Sciences, 12, 5-12.
5. Deutsch, M.U., Maw, G.J., Jenkins, D., & Reaburn, P. (1998). Heart rate, blood lactate and kinematic data of elite colts (under-19) rugby union players during competition. *Journal of Sports Sciences, 16,* pp.561-570.
6. Ellis, P.D. (2010). *The Essential Guide to Effect Sizes: Statistical Power, Meta-Analysis, and the Interpretation of Research Results*. New York, USA: Cambridge University Press.
7. Erčulj, F., Dežman, B., Vučković, G., Perš, J., Perše, M., & Kristan, M. (2008). An analysis of basketball players’ movements in the Slovenian basketball league play-offs using the SAGIT tracking system. Facta Universitatis. *Physical Education and Sport, 6*(1), pp.75-84.
8. Gocentas, A., Landõr, A., & Kriščiūnas, A. (2011). Heart rate recovery changes during competition period in high-level basketball players. Education. *Physical training. Sport, 1*(80), pp.11-16.
9. Hoffman, J.R. (2002). *Physiological aspects of sport training and performance.* Champaign, IL, USA: Human Kinetics.
10. Hoffman, J.R. (2003). Physiology of basketball. In McKeag, D.B. (Ed.) *Basketball. Handbook of sport medicine and science.* Oxford, UK: Blackwell Science Ltd.
11. Hůlka, K., Cuberek, R., & Bělka, J. (2013). Heart rate and time-motion analysis in top junior players during basketball matches. *Acta Universitatis Palackianae Olomucensis. Gymnica, 43*(3), pp.27-35.
12. Kenney, W.L., Wilmore, J.H., & Costill, D.L. (2012). *Physiology of sport and exercise* (5th ed.). Champaign, IL, USA: Human Kinetics.
13. Klusemann, M.J., Pyne, D.B., Foster, C., & Drinkwater, E.J. (2012). Optimising technical skills and physical loading in small-sided basketball games. *Journal of Sports Sciences, 30*(14), pp.1463-1471
14. Krustrup, P., Mohr, M., Ellingsgaard, H., & Bangsbo, J. (2005). Physical Demands during an Elite Female Soccer Game: Importance of Training Status. Medicine and Science in Sports and Exercise, 37(7), pp.1242-1248.
15. Léger, L.A., Mercier, D., Gadoury, C., & Lambert, J. (1988). The multistage 20 metre shuttle run test for aerobic fitness. *Journal of Sports Sciences, 6,* pp.93-101.
16. McInnes, S.E., Carlson, J.S., Jones, C.J., & McKenna, M.J. (1995). The physiological load imposed on basketball players during competition. *Journal of Sports Sciences, 13*(5), pp.387-397.
17. Matthew, D., & Delextrat, A. (2009). Heart rate, blood lactate concentration, and time-motion analysis of female basketball players during competition. *Journal of Sports Sciences, 27*(8), pp.813-821.

18. Montgomery, P.G., Pyne, D.B., & Minahan, C.L. (2010). The Physical and Physiological Demands of Basketball Training and Competition. *International Journal of Sports Physiology and Performance, 5,* pp.75-86.
19. Narazaki, K., Berg, K., Stergiou, N., & Chen, B. (2009). Physiological demands of competitive basketball. *Scandinavian Journal of Medicine & Science in Sports, 19*(3), pp.425-432.
20. Pettitt, R.W., Pettitt, C.D., Carbera, C.A., & Murray, S.T. (2007). A theoretical method of using heart rate to estimate energy expenditure during exercise. *International Journal of Sports Science & Coaching, 2*(3), pp.319-327.
21. Rodríguez-Alonso, M., Fernández-García, B., Pérez-Landaluce, J., & Terrados, N. (2003). Blood lactate and heart rate during national and international women's basketball. *Journal of Sports Medicine and Physical Fitness, 43*(4), pp.432-436.
22. Scanlan, A.T., Dascombe, B.J., & Reaburn, P. (2011). A comparison of the activity demands of elite and sub-elite Australian men's basketball competition. *Journal of Sports Sciences, 29*(11), pp.1153-1160.
23. Scanlan, A.T., Dascombe, B.J., Reaburn, P., & Dalbo, V.J. (2012). The physiological and activity demands experienced by Australian female basketball players during competition. *Journal of Science and Medicine in Sport, 15,* pp.341-347.
24. Tessitore, A., Tiberi, M., Cortis, C., Rapisarda, E., Meeusen, R., & Capranica, L. (2006). Aerobic-Anaerobic Profiles, Heart Rate and Match Analysis in Old Basketball Players. *Gerontology, 52,* pp.214-222.
25. Thomas, J.R., Nelson, J.K., & Silverman, S.J. (2011). *Research methods in physical activity* (4th ed.). Champaign, IL, USA: Human Kinetics.
26. Trninić, S., Karalejić, M., Jakovljević, S., & Jelaska, I. (2010). Structural analysis of knowledge based on principal attributes of the game of basketball. *Physical Culture, 64*(1), pp.5-25.
27. Vaquera, A., Refoyo, I., Villa, J.G., & Calleja, J., Rodríguez-Marroyo, J.A., García-López, J. & Sampedro, J. (2008). Heart rate response to game-play in professional basketball players. *Journal of Human Sport and Exercise, 3*(1), pp.1-9.
28. Ziv, G., & Lidor, R. (2009). Physical Attributes, Physiological Characteristics, On-Court Performances and Nutritional Strategies of Female and Male Basketball Players. *Sports Medicine, 39*(7), pp.547-568.

