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How hormones, vertical jump and perceived exertion change in clutch time. A season case study of an amateur basketball team

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ABSTRACT

Basketball clutch time is defined as minutes when the scoring margin is within 5 points with five or fewer minutes remaining in a game. Our aims were to explore the relations and to compare testosterone and cortisol behaviours, vertical jump (CMJ) and perceived exertion (RPE) between clutch time games (CT) and non-clutch time games (N-CT); during a season in an amateur male team (24.02 ± 3.36 years). Data was collected at 22 games considering CT ($n = 8$) or N-CT ($n = 14$) depending on the scoring margin with five or fewer minutes. A total of 120 player cases who participated in the last 5 min of each game (CT, $n = 48$; N-CT, $n = 72$) were analysed using a mixed linear model for repeated measures to compare the CT and N-CT variations. The main results were Cortisol, CMJ and RPE means turned out to be higher in CT, but relevant differences were only identified for RPE (ES = 0.69). Findings suggested that clutch performance was often viewed through players' subjective parameters. Consequently, we recommend that both players and coaches consider it for CT performance. In addition, we extend current basketball CT indicator knowledge opening future research and applied practice.

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Team sport; testosterone; cortisol; countermovement jump; RPE

1. Introduction

Clutch performance has been defined as "any performance increment or superior performance that occurs under pressure circumstances" (Otten, 2009). In a basketball game, clutch time is referred as minutes when the scoring margin is within 5 points with five or fewer minutes remaining in a game (Solomonov et al., 2015). For this, the importance of possessions and the players performance during the final minutes of a basketball game is often crucial to the success of a team (Solomonov et al., 2015). Among other aspects, the identification of clutch performance has focused on objective scores as an event-focused interview (Schweickle et al., 2021), basketball shooting (Otten,

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2009), the effects of psychological pressure on performance using National Basketball Association (NBA) free throw (Cao et al., 2011), and performance statistics (i.e. shots, blocks, steals, assists, rebounds. . .) (Schweickle et al., 2021). Specifically, these actions require an increase in the physical capacities inherent of basketball: speed, strength, endurance. . . with contributions from both aerobic and an-aerobic energy requirements (Schelling & Torres-Ronda, 2016). In this line and to the best of our knowledge, the biomarkers, the physical and motor abilities and perceived exertion responses during clutch time have not yet been studied. In addition, in the study of Solomonov et al. (2015) concluded that most elite athletes do not necessarily choke under competitive pressure conditions. However, should this conclusion be extrapolated to an amateur context?

With regard to biomarkers, saliva collection is an easy and non-invasive method to measure hormones which is proposed as a practical and reliable method in basketball (Kamarauskas & Conte, 2022). Biomarkers like testosterone (T) and cortisol (C) have been proposed as indicators of anabolic and catabolic processes in physical exercise (Kamarauskas & Conte, 2022) and they have been related to perceived exertion by basketball players across a competitive season (Robazza et al., 2012). Basketball official games have been shown to be characterised by high physical and physiological demands, leading to increased physical and psychophysiological stress (Petway et al., 2020; Stojanović et al., 2018). In this sense, C concentration is an important link between anxiety state (typical of clutch time) and subsequent physical performance in elite basketball athletes (Arruda et al., 2014). Moreover, according to Wood and Stanton (2012) the positive association between T and motivation level suggests that individuals with high level of T may be the most motivated individuals to engage in athletic competition. It has also been reported positive correlations between perceived exertion and C changes, as well as absolute concentrations of salivary C after hard workout and official game (He et al., 2010).

In basketball, vertical jump is an important part of the defensive (i.e. defensive rebound, jump for the ball in the beginning of the game, blocking shots) and offensive skills (i.e. offensive rebound, shooting, passing the ball from the jump) (Ranisavljev et al., 2018). Basketball players perform two jumps per minute (Delextrat et al., 2017), although this value may vary depending on playing position and the quarter (García et al., 2020). A general decline in physical performance due to the fatigue caused by the high physical demands (Stojanović et al., 2018) of the official game development could be obvious; nevertheless, it is controversial whether to affirm these physical demands tend to diminish at the end of basketball games. While some studies have not been able to report significant differences by quantifying speed and jump parameters in males (García et al., 2020; Scanlan et al., 2015), other investigations have found a significant decrease between the first and last quarter in high-intensity actions as a jump ability (Delextrat et al., 2017; Vázquez-Guerrero et al., 2019). While these results were obtained in professional players, only one study has been carried out with amateur basketball players (Fernández-Leo et al., 2020). These authors did not find differences in the number of jumps performed when the score difference was small, but a lower intensity (measured as a percentage of maximum heart rate) was reported during the second half (Q3 and Q4) of the game. Nevertheless, no study carried out with amateur basketball players has investigated the effects of basketball clutch time on vertical jump and its potential decrease in terms of jump height.

Despite basketball is one of the most played and recognised sports in the world (Sarlis & Tjortjis, 2020), there is currently a lack of research into the clutch time and physical responses. Literature pertaining to this topic is extremely limited and as far as we are aware, this is the first study focused on physical and subjective consequences in clutch time in amateur basketball players. For this, the main purpose of this research was to compare the hormonal (T and C), the vertical jump and the perceived exertion responses between clutch time and non-clutch time during an entire season in an amateur male team. On the basis of the previous studies, we can hypothesise that the clutch time (due to the crucial moment of the game) involve an essential energy expenditure and a special mental fatigue, which may reduce the testosterone levels and the vertical jump performance and increase the cortisol levels and the perceived exertion.

2. Methods

2.1. Study design

We used a repeated measures design to evaluate the possible effects of clutch time context during a basketball season (October–April) on T and C hormones, vertical jump and perceived exertion in amateur players. In order to determine the influence of clutch time games, the research was conducted during the 22 official federation games from 120 player cases who participated in the last 5 min of each game. This study was conducted in accordance with the guidelines found in the Helsinki Declaration, which establishes ethical principles for investigations in humans. Participants provided informed consent before the study commenced and all procedures received the approval of local ethics committee (ULE-022-2021). To standardise the procedure, all tests were performed using the same protocol and in the same order post game: saliva sample collection, RPE test and vertical jump assessment.

2.2. Sample

The subjects were amateur male basketball players ($n = 12$; mean ± SD, age: 24.02 ± 3.36 years; height: 1.88 ± 0.08 m; body mass: 87.03 ± 7.34 kg and body mass index: 24.51 ± 0.91) who competed with the same team in the Spanish fifth division during the 2022/2023 season. Sample inclusion criteria were that the players: (a) have played ≥2 min over the last 5 min of the game and (b) have played ≥20 min of the game. Following these premises and considering that previous research has defined the final 5 min of a game during which the score margin is less than or equal to five points as clutch time (Eppel et al., 2023; Solomonov et al., 2015), the sample was divided into CT (clutch time) and N-CT (non-clutch time) groups. Out of the 22 games analysed, 8 were resolved under CT conditions, and 14 under N-CT conditions. Demographic characteristics of these groups at the beginning of the season can be observed in Table 1. It is worth noting that overtime was also considered a clutch time context because, in basketball, its duration is 5 min, and the teams begin with a tied score.

Table 1. Demographic characteristics of CT and N-CT groups.

	CT ($n = 48$)		N-CT ($n = 72$)		
	Mean	SD	Mean	SD	p
Age (years)	24.1	3.38	23.97	3.38	0.837
Height (m)	1.89	0.08	1.87	0.08	0.182
Body mass (kg)	85.81	7.46	87.86	7.21	0.135
Body mass index	24.46	0.89	24.54	0.94	0.642

Abbreviations: CT, clutch time; N-CT, non-clutch time. p-value; $*p < .05$.

2.3. Hormonal assessments

For the purpose of assessing T and C concentrations, subjects provided two saliva samples per game: 20–24 h before (PRE-game) and within 15 min of the completion (POST-game) on the locker room. The samples were collected in a pre-weighed sterile 15-mL centrifuge tube over a five-minute period and stored at − 80 °C until assay. The tubes were re-weighed before analysis, so that saliva volume could be estimated. Saliva density was assumed to be 1.00 $g·mL^{-1}$. Salivary flow rate was determined by dividing the volume of saliva collected by the duration of the sampling period. After thawing and centrifugation (10,000 g for 10 min at 4 °C), the samples were tested for T and C concentrations using enzyme-linked immunosorbent assays (ELISA, Salimetrics™ expanded range kit) and the manufacturer's recommendations. The average intra-assay coefficient of variation for the T and C assays were 3.7% and 3.2%, respectively. The minimum detection limit for the T assay was 21 pmol/L and 0.33 nmol/L for the C assay. The testosterone-cortisol (T/C) ratio was estimated using the equation: $T/C = T \times 100/C$

2.4. Rate of perceived exertion

The reporting of rate of perceived exertion (RPE) was used as a subjective parameter of exercise intensity and was employed according to the protocol described by Foster et al. (1995) just after saliva sample collection on the locker room. The RPE scale is a category-ratio scale characterised by scores and verbal links (i.e. from "rest" to "maximal"), referring the participant's perception of efforts to a numerical score between 0 (i.e. rest) and 10 (i.e. maximal).

2.5. Vertical jump

The vertical jump height (counter-movement jump-CMJ) was evaluated 20–24 h before game and within 15 min of the completion using a force plate (Kistler 9253B11, Kistler Instrument AG, Winterthur, Switzerland) placed in a small area adjacent to the corner of the court. Players performed the CMJ according to previously described protocols (Bosco et al., 1983) and following the recommendations of Kozinc and Pleša (2023). Players made three attempts with 45–60 seconds' rest between jumps (Warr et al., 2020), with no arm swing and keeping their hands at the waist followed by a maximal effort vertical jump and landed on the floor. The best result was assessed for the CMJ variable.

2.6. Statistical analysis

The normality of the distribution was assumed according to Hopkins et al. (2009). According to Raudenbush and Bryk (2002), to compare the variations in CT and N-CT values mixed linear models for repeated measures were employed, being player identifier the random factor and group of games and measure: pre-post variables the fixed factors. These models were chosen to account for individual variability and provide robust insights into the relationships between these variables and performance outcomes. On the one hand, R-squared was calculated to consider the goodness-of-fit considering the impact of random effects and individual variability. On the other hand, marginal R-squared was calculated to assess the independent contribution of fixed factors to the variability in the response variable. Finally, the Intraclass Correlation Coefficient (ICC) was assessed to provide insights into the impact of individual differences or random effects on the response variable. Practical significance was assessed by calculating effect sizes (*ES*) between 0.0–0.2, 0.2–0.6, 0.6–1.2, 1.2–2.0, and 2.0–4.0 were considered as trivial, small, moderate, large, and very large, respectively (Hopkins et al., 2009). It was assessed percentage of change between CT and N-CT. Simple linear regression equations and *r*-squared (r^2) values were conducted to determine the relation between post-game values in T, C and CMJ with the percentages of variation PRE-POST in T (Δ%_T), C (Δ%_C) and CMJ (Δ%_CMJ). The significance level was set at $p < .05$. Data analyses were conducted with the Python data analysis library Pandas (v.2.0.3) and Statsmodels (2.0.3).

3. Results

Table 2 shows the descriptive results (means and SD´s) and the percentage of change between PRE-game and POST-game in CT and N-CT in all variables. In POST-game assessment, the highest value of change between CT and N-CT was found in RPE (CT = 7.69; N-CT = 6.90; % = 11.57%). In addition, cortisol and CMJ means turned out to be slightly higher in CT.

POST-game results of the magnitude of the differences between CT and N-CT for all variables are shown in Figure 1. Only relevant differences have been identified for RPE (*ES* = 0.69, moderate).

Figure 2 shows, for CT and N-CT, the correlation matrix among POST-game values in T, C, T/C and CMJ with the percentages of variation PRE-POST in T (Δ%

Table 2. Descriptive results and percentage of change between PRE-game and POST-game in CT and N-CT.

	CT ($n = 48$)					N-CT ($n = 72$)					
	PRE-game		POST-game			PRE-game		POST-game			
	Mean	SD	Mean	SD	Δ%	Mean	SD	Mean	SD	Δ%	*p* (Δ%)
T (pmol·L − 1)	655.23	46.76	820.56	102.99	24.73	661.00	61.36	847.88	107.79	28.06	0.002*
C (nmol·L − 1)	21.15	3.13	26.34	2.77	25.18	21.10	2.87	25.75	3.12	22.78	0.978
T/C	3,081.10	499.08	3,078.56	400.69	0.08	3,105.51	586.78	3,225.40	693.28	−3.86	0.036
CMJ (cm)	44.41	6.75	42.21	4.28	−4.72	44.02	7.03	42.14	4.53	−4.31	0.752
RPE (ua)	n/a		7.69	1.15	n/a	n/a		6.90	1.30	n/a	n/a

Abbreviations: CT, clutch time; N-CT, non-clutch time; T, testosterone; C, cortisol; T/C, ratio testosterone-cortisol; CMJ, counter movement jump; RPE, rate of perceived exertion; Δ% percentage of change between PRE game and POST game in CT and N-CT; n/a, not applicable. p-value; *$p < .05$.

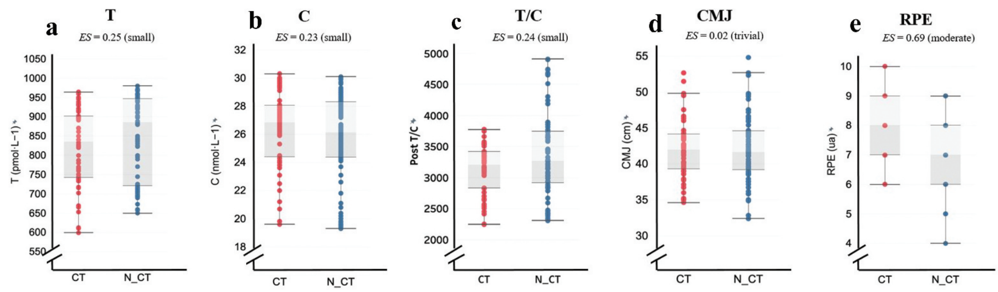

Figure 1. Differences between CT (clutch time) (red dots) and N-CT (non-clutch time) (blue dots) on testosterone (T) (panel A), cortisol (C) (panel B), ratio testosterone-cortisol (T/C) (panel C); counter-movement jump (CMJ) (panel D) and rate of perceived exertion (RPE) (panel E). *ES*, effect size. Boxplots are shown with medians, first and third quantiles, range (1.5 times the interquartile range), and outliers beyond the range.

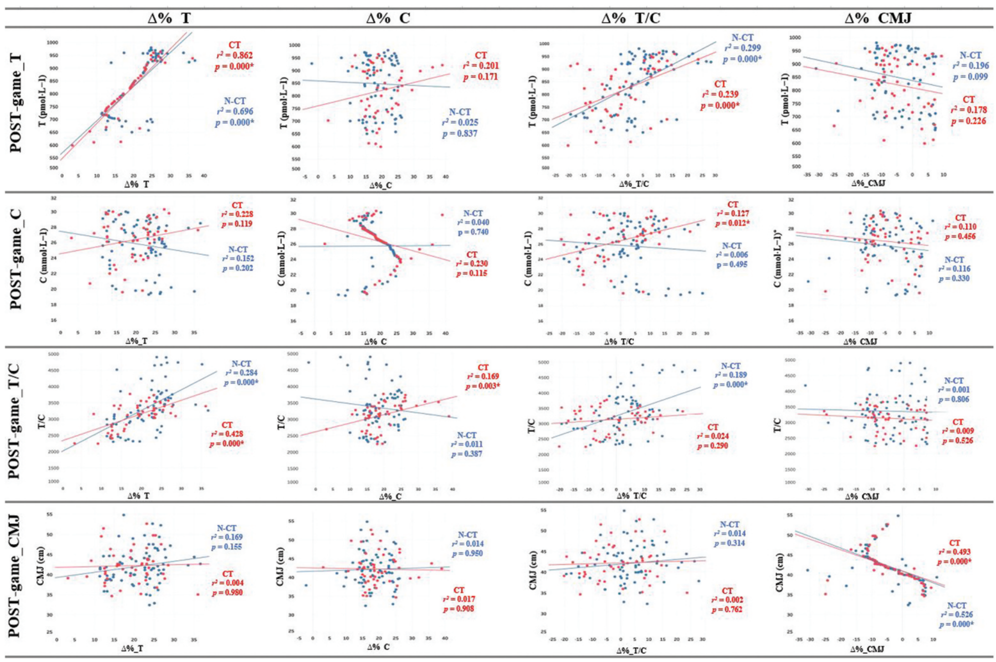

Figure 2. Correlation matrix among post game values in testosterone (POST-game_T), cortisol (POST-game_C), ratio testosterone-cortisol (POST-game_T/C) and counter movement jump (POST-game _CMJ) with the percentages of variation pre-post game in T (Δ%_T), C (Δ%_C), T/C (Δ%_T/C) and CMJ (Δ%_CMJ) for clutch time games (CT) (red dots) and non-clutch times games (N-CT) (blue dots). Notes: r^2, *r*-squared; *p*, *p*-value; $^*p < .05$.

_T), C (Δ%_C), T/C (Δ%_T/C) and CMJ (Δ%_CMJ). Regression analysis showed that POST-game T was a factor that contributed significantly to the variation in PRE-POST T for CT ($r^2 = 0.862$; $p < 0.000$) and N-CT ($r^2 = 0.696$; $p < 0.000$); POST-game T too contributed significantly to the variation in PRE-POST T/C for CT

Table 3. Results of the mixed linear models considering both clutch moments (CT) and non-clutch moments (N-CT).

Moment	Variable	Marginal r^2	Conditional r^2	ICC
PRE game	T	0.012	−0.109	$4.617 \cdot 10^{-7}$
PRE game	C	2.803	0.772	0.942
PRE game	CMJ	0.269	0.082	0.293
POST game	T	0.027	0.009	$9.931 \cdot 10^{-5}$
POST game	C	2.727	0.749	0.933
POST game	CMJ	0.247	0.075	0.281
	RPE	0.158	0.047	$3.083 \cdot 10^{-9}$

Abbreviations: ICC, Intraclass Correlation Coefficient; r^2, r-squared.

($r^2 = 0.239$; $p < 0.000$) and N-CT ($r^2 = 0.299$; $p < 0.000$); and in Post-game CMJ for CT ($r^2 = 0.493$; $p < 0.000$) and N-CT ($r^2 = 0.526$; $p < 0.000$).

Table 3 shows the results of the mixed linear models for considering CT and N-CT in all variables.

For PRE-POST game T measures data in Table 3 show marginal r-squared values of 0.012 and 0.027, respectively, suggesting that these variables explain only a small portion of the variance in sports performance. The conditional r-squared values were −0.109 and 0.009, respectively. Notably, the ICC values for both testosterone measures were quite low, indicating minimal influence of individual variability on these measures.

In contrast, the data in Table 3 indicate that PRE-POST game Cl exhibits substantial marginal R-squared values of 2.803 and 2.727, respectively, indicating a more significant contribution to performance variance. The conditional r-squared values were 0.772 and 0.749, respectively, suggesting that accounting for individual variability enhances their explanatory power. The ICC values for both cortisol measures were notably high at 0.943 and 0.933, respectively, indicating a substantial influence of individual differences on these variables.

CMJ showed marginal R-squared values of 0.269 and 0.247, respectively, suggesting a moderate impact on performance variance (Table 3). The conditional r-squared values were, respectively, 0.082 and 0.075, respectively, indicating that considering individual variability slightly improves their explanatory power. The ICC values were in the range of 0.293 to 0.281, signifying a moderate influence of individual differences.

RPE exhibited a marginal r-squared value of 0.158, indicating a moderate contribution to performance variance (Table 3). The conditional r-squared value for RPE was 0.0479, highlighting its influence when considering individual variability. Finally, the ICC value for RPE was $3.083 \cdot 10^{-9}$, suggesting minimal influence of individual differences on this variable.

4. Discussion

In response to the paucity of studies conducted in basketball clutch time situation, we compared the T & C behaviours, vertical jump (CMJ) and perceived exertion (RPE) between clutch time games (CT) and non-clutch time games (N-CT); and we explored the relations between these variables during an entire season. We demonstrated that C, CMJ and RPE means turned out to be higher in CT, but only relevant differences were identified for RPE ($ES = 0.69$, moderate). In addition, RPE demonstrated relatively low

ICC values ($3.083{\cdot}10^{-9}$), suggesting that individual differences in perceived exertion have minimal impact on overall performance. So, the results suggested that clutch performance were often viewed through a subjective lens. Based on the correlation analysis, *r*-squared accounted for a significant amount of the variability only in the cases POST-game T with the variation PRE-POST_T, PRE-POST_T/C and in POST-game CMJ with the variation PRE-POST_CMJ, in both groups (CT and N-CT). These findings reported turn out to be inconsistent with the hypothesis that CT may reduce the vertical jump performance due to physical fatigue; in addition, testosterone levels were reduced (as an extra energy expenditure due to the crucial moment of the game) and increase the C levels and the perceived exertion, but these variations were non-significant comparing CT and N-CT games. However, our analysis underscores the importance of considering individual variability when evaluating sports performance. Variables such as PRE_C and POST_C exhibited high ICC values (0.942 and 0.933 in PRE and POST game, respectively), indicating that individual differences among athletes significantly contribute to the variance in these metrics.

The increase in salivary hormone values throughout the game has been supported by previous research conducted in the context of basketball (Arruda et al., 2014; Moreira et al., 2012). However, one of the main and novel findings of the current study was the impact of the opportunity to win the game, commonly referred to as clutch time, on salivary hormone concentrations. Specifically, our study found that winning during clutch time led to an increase in salivary C levels, while T concentrations decreased. The results of our mixed linear model in PRE and POST T showed limited influence on performance, with low r-squared and ICC values. These findings challenge the conventional wisdom surrounding T levels, suggesting that other factors might play a more prominent role in performance outcomes. In this sense, while a previous study in wrestling competitions reported greater increases in T concentration with winning as opposed to losing (Fry et al., 2011), team sports such as basketball involve various factors that can moderate hormonal responses to competition. These factors include concentration disruption (Madrigal & Wilson, 2017), physical fitness, physical effort and exertion, mood, appraisal and satisfaction of the outcome, motivation, self-efficacy, anxiety, coping styles (Moreira et al., 2012), and, in our case, the specific moment within the game. Furthermore, the observed elevation in the rate of perceived exertion during CT games, compared to N-CT games, aligns with the findings of Scanlan et al. (2019), who highlighted that overtime games disproportionately elevate RPE, physiological behaviour, and acceleration workloads compared to regular games. Despite its moderate marginal r-squared value, RPE showed a relatively low conditional R-squared value, indicating that its influence becomes more pronounced when accounting for individual variability. This implies that while RPE alone may not explain a significant portion of performance variance, it plays a more substantial role when considered alongside individual differences among athletes. For this, integrating subjective assessments like RPE into performance monitoring can provide a more holistic understanding of an athlete's state during training or competition (Bar-Eli & Tractinsky, 2000; Robazza et al., 2012). Interestingly, Schweickle et al. (2021) suggest that athletes' perceptions of their performance in clutch time situations are important to consider and may not necessarily align with traditional objective performance indicators such as performance statistics. In our study, we expand upon this notion by examining objective physical indicators, specifically biomarkers in the form of salivary hormone concentrations, to provide a more comprehensive understanding of performance dynamics during clutch time in basketball.

By exploring both subjective and objective measures, our findings shed light on the complex interplay between psychological and physiological factors that influence individual performance in basketball during critical moments of the game. These insights contribute to a deeper understanding of the physiological responses and performance indicators associated with clutch time situations, ultimately enhancing our knowledge of optimal performance in basketball. Our results did not support the hypothesis that vertical jump would decrease in CT games. In this sense, it is necessary to consider that tactical factors may influence towards the end of a game rather than physical. Abdelkrim et al. (2007) informed that during the last minutes of a game, teams are likely to manage a further control of ball possession, and therefore, the proportion of straight play and fast breaks decreases, causing the whole pace to slow down. In addition, although the players' fatigue could have a negative effect on some physical variables in the last minutes, tactical principles, including more stoppages and consequently a longer period duration, could better explain the game load output in the last minutes of the game (García et al., 2020). In this respect, the final phase of the game is characterised as comprising twice as many highly critical possessions than low-criticality possessions, thus producing lower quality of decision-making due to the stress and the RPE (Bar-Eli & Tractinsky, 2000). In this line, future research is needed to investigate the role of different tactical aspects and game strategies on the movement patterns of players (as isolations, picks or post-ups), and the possible impact of players' mental strength in these pressure situations.

The findings of the present study offer further insight into hormone behaviour, vertical jump, and perceived exertion responses that amateur basketball players experience in CT games. Nevertheless, there are some limitations of this study that should be considered: Firstly, to provide more comprehensive detail, we could have considered the perceived game load by multiplying the perceived exertion value by the seconds played by game for each player; Secondly, the fact that it was only possible to categorise a team means that conclusions were reduced to a case study; Finally, another potential limitation could be the use of game load averages by comparing the variations pre- and post-game. Therefore, future studies are needed to examine the physical, psychological and physiological stress responses of basketball players during clutch time games, including amateur, elite or young (female and female) sample.

5. Conclusions

In conclusion, the current study indicated that clutch time games elevate perceptual exertions. In addition, the variations on objective indicators as T & C behaviours and vertical jump, were non-significant comparing CT games and N-CT games. For this, we suggest that both players and their coaches consider subjective parameters for CT performance. Lastly, these conclusions extend current knowledge of indicators of basketball CT opening future research and applied practice.

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No potential conflict of interest was reported by the author(s).

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References

Abdelkrim, N. B., El Fazaa, S., & El Ati, J. (2007). Time–motion analysis and physiological data of elite under-19-year-old basketball players during competition. *British Journal of Sports Medicine*, *41*(2), 69–75. https://doi.org/10.1136/bjsm.2006.032318

Arruda, A. F., Aoki, M. S., Freitas, C. G., Drago, G., Oliveira, R., Crewther, B. T., & Moreira, A. (2014). Influence of competition playing venue on the hormonal responses, state anxiety and perception of effort in elite basketball athletes. *Physiology & Behavior*, *130*, 1–5. https://doi.org/10.1016/j.physbeh.2014.03.007

Bar-Eli, M., & Tractinsky, N. (2000). Criticality of game situations and decision making in basketball: An application of performance crisis perspective. *Psychology of Sport and Exercise*, *1*(1), 27–39. https://doi.org/10.1016/S1469-0292(00)00005-4

Bosco, C., Luhtanen, P., & Komi, P. V. (1983). A simple method for measurement of mechanical power in jumping. *European Journal of Applied Physiology and Occupational Physiology*, *50*(2), 273–282. https://doi.org/10.1007/BF00422166

Cao, Z., Price, J., & Stone, D. F. (2011). Performance under pressure in the NBA. *Journal of Sports Economics*, *12*(3), 231–252. https://doi.org/10.1177/1527002511404785

Delextrat, A., Badiella, A., Saavedra, V., Matthew, D., Schelling, X., & Torres-Ronda, L. (2017). Match activity demands of elite Spanish female basketball players by playing position. *International Journal of Performance Analysis in Sport*, *15*(2), 687–703. https://doi.org/10.1080/24748668.2015.11868824

Eppel, Y., Kaspi, M., & Painsky, A. (2023). Decision making for basketball clutch shots: A data driven approach. *Journal of Sports Analytics*, *Preprint*, 1–16. https://doi.org/10.3233/JSA-220682

Fernández-Leo, A., Gómez-Carmona, C. D., García-Rubio, J., & Ibáñez, S. J. (2020). Influence of contextual variables on physical and technical performance in male amateur basketball: A case study. *International Journal of Environmental Research and Public Health*, *17*(4), 1193. https://doi.org/10.3390/ijerph17041193

Foster, C., Hector, L. L., Welsh, R., Schrager, M., Green, M. A., & Snyder, A. C. (1995). Effects of specific versus cross-training on running performance. *European Journal of Applied Physiology and Occupational Physiology*, *70*(4), 367–372. https://doi.org/10.1007/BF00865035

Fry, A. C., Schilling, B. K., Fleck, S. J., & Kraemer, W. J. (2011). Relationships between competitive wrestling success and neuroendocrine responses. *Journal of Strength & Conditioning Research*, *25*(1), 40–45. https://doi.org/10.1519/JSC.0b013e3181fef62f

García, F., Vázquez-Guerrero, J., Castellano, J., Casals, M., & Schelling, X. (2020). Differences in physical demands between game quarters and playing positions on professional basketball players during official competition. *Journal of Sports Science & Medicine*, *19*(2), 256.

He, C. S., Tsai, M. L., Ko, M. H., Chang, C. K., & Fang, S. H. (2010). Relationships among salivary immunoglobulin A, lactoferrin and cortisol in basketball players during a basketball season. *European Journal of Applied Physiology*, *110*(5), 989–995. https://doi.org/10.1007/s00421-010-1574-8

Hopkins, W. G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine & Science in Sports & Exercise*, *41*(1), 3–12. https://doi.org/10.1249/mss.0b013e31818cb278

Kamarauskas, P., & Conte, D. (2022). The effect of basketball matches on salivary markers: A systematic review. *Biology of Sport*, *39*(4), 791–808. https://doi.org/10.5114/biolsport.2022.107481

Kozinc, Ž., & Pleša, J. (2023). Discrepancy among different methods for vertical jump height determination and its implications for field-based testing: A narrative review. *Measurement in Physical Education and Exercise Science*, *27*(3), 248–256. https://doi.org/10.1080/1091367X.2022.2163398

Madrigal, L. A., & Wilson, P. B. (2017). Salivary hormone and anxiety responses to free-throw shooting competition in collegiate female basketball players. *Journal of Clinical Sport Psychology*, *11*(3), 240–253. https://doi.org/10.1123/jcsp.2016-0034

Moreira, A., McGuigan, M. R., Arruda, A. F., Freitas, C. G., & Aoki, M. S. (2012). Monitoring internal load parameters during simulated and official basketball matches. *Journal of Strength & Conditioning Research*, *26*(3), 861–866. https://doi.org/10.1519/JSC.0b013e31822645e9

Otten, M. (2009). Choking vs clutch performance: A study of sport performance under pressure. *Journal of Sport and Exercise Psychology*, *31*(5), 583–601. https://doi.org/10.1123/jsep.31.5.583

Petway, A. J., Freitas, T. T., Calleja-Gonzalez, J., Medina Leal, D., Alcaraz, P. E., & Balsalobre-Fernández, C. (2020). Training load and match-play demands in basketball based on competition level: A systematic review. *PloS One*, *15*(3), e0229212. https://doi.org/10.1371/journal.pone.0229212

Ranisavljev, I., Mandić, R., Ćosić, M., & Blagojević, P. (2018). *The relationship between vertical jump performance and number of rebounds during nba games*. [International Scientific Conference: Effects of physical activity application to anthropological starus with children, adolescencent and adults], Belgrade, Republic of Serbia. University of Belgrade.

Raudenbush, S. W., & Bryk, A. S. (2002). Hierarchical linear models: Applications and data analysis methods. *Contemporary Sociology*, *22*(2), 293–295. https://doi.org/10.2307/2075823

Robazza, C., Gallina, S., D'Amico, M. A., Izzicupo, P., Bascelli, A., DiFonso, A., Mazzaufo, C., Capobianco, A., & DiBaldassarre, A. (2012). Relationship between biological markers and psychological states in elite basketball players across a competitive season. *Psychology of Sport and Exercise*, *13*(4), 509–517. https://doi.org/10.1016/j.psychsport.2012.02.011

Sarlis, V., & Tjortjis, C. (2020). Sports analytics — evaluation of basketball players and team performance. *Information Systems*, *93*, 101562. https://doi.org/10.1016/j.is.2020.101562

Scanlan, A. T., Stanton, R., Sargent, C., O'Grady, C., Lastella, M., & Fox, J. L. (2019). Working overtime: The effects of overtime periods on game demands in basketball players. *International Journal of Sports Physiology and Performance*, *14*(10), 1331–1337. https://doi.org/10.1123/ijspp.2018-0906

Scanlan, A. T., Tucker, P. S., Dascombe, B. J., Berkelmans, D. M., Hiskens, M. I., & Dalbo, V. J. (2015). Fluctuations in activity demands across game quarters in professional and semiprofessional male basketball. *Journal of Strength & Conditioning Research*, *29*(11), 3006–3015. https://doi.org/10.1519/jsc.0000000000000967

Schelling, X., & Torres-Ronda, L. (2016). An integrative approach to Strength and neuromuscular power training for basketball. *Strength and Conditioning Journal*, *38*(3), 72–80. https://doi.org/10.1519/ssc.0000000000000219

Schweickle, M. J., Swann, C., & Vella, S. A. (2021). Objective and subjective performance indicators of clutch performance in basketball: A mixed-methods multiple case study. *Journal of Applied Sport Psychology*, *35*(2), 1–23. https://doi.org/10.1080/10413200.2021.1998805

Solomonov, Y., Avugos, S., & Bar-Eli, M. (2015). Do clutch players win the game? Testing the validity of the clutch player's reputation in basketball. *Psychology of Sport and Exercise*, *16*, 130–138. https://doi.org/10.1016/j.psychsport.2014.10.004

Stojanović, E., Stojiljković, N., Scanlan, A. T., Dalbo, V. J., Berkelmans, D. M., & Milanović, Z. (2018). The activity demands and physiological responses encountered during basketball match-play: A systematic review. *Sports Medicine*, *48*(1), 111–135. https://doi.org/10.1007/s40279-017-0794-z

Vázquez-Guerrero, J., Fernández-Valdés, B., Jones, B., Moras, G., Reche, X., Sampaio, J., & Marocolo, M. (2019). Changes in physical demands between game quarters of U18 elite official basketball games. *PloS One*, *14*(9), e0221818. https://doi.org/10.1371/journal.pone.0221818

Warr, D. M., Pablos, C., Sánchez-Alarcos, J. V., Torres, V., Izquierdo, J. M., Redondo, J. C., & Lu, Z. (2020). Reliability of measurements during countermovement jump assessments: Analysis of performance across subphases. *Cogent Social Sciences*, *6*(1), 1843835. https://doi.org/10.1080/23311886.2020.1843835

Wood, R. I., & Stanton, S. J. (2012). Testosterone and sport: current perspectives. *Hormones and Behavior*, *61*(1), 147–155. https://doi.org/10.1016/j.yhbeh.2011.09.010