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The Relationship between Pass Completion Percentage and Perceived Player Workload in NCAA Division I Women's Soccer

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by

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ABSTRACT

In an attempt to demonstrate the interconnecting nature of the pillars of sport (Hacker, 2000) this thesis explores the relationship between physical, psychological and technical variables. Five National Collegiate Athletic Association (NCAA) Division I Women's Soccer players were analysed in four conference matches. The athlete's rate of perceived exertion (RPE) values were correlated to pass completion percentages (PC%) to investigate the potential effect that psychological satisfaction or dissatisfaction of technical performance has on perceived exertion ratings. PlayerLoad™ (PL) values, gathered through the utilization of a Catapult Minimax S4 GPS device (miniMax-10 Hz, Catapult Innovations, Melbourne, Australia), were used as a measure of actual workload in order to determine the accuracy of perceived exertion ratings. Results exhibited a trivial correlation ($r = 0.028$) and large variability ($R^2 = 0.00077$) between RPE and PC% in comparison to PL and PC% ($r = 0.50$; $R^2 = 0.2502$). The results indicate that an athlete's PC% does not correspond to how physically demanding they perceived a match to be. However, it is possible that performance variables may influence the RPE ratings a player provides.

DEDICATION & ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION

Statement of Problem

The four pillars of sport essential to competitive excellence are technical, tactical, physiological, and psychological (Hacker, 2000). Players and coaches scrutinize these aspects in the pursuit of ascertaining the minute differences between success and failure. As such, the effective use of feedback and monitoring to understand the demands of sport, particularly soccer, has become immensely important. With the myriad of demands and characteristics that can determine the success of an individual player and team, coaches are constantly searching for a better understanding (Alexander, 2014).

Player feedback is a substantial and telling method for monitoring. Significant research has been completed on rate of perceived exertion (RPE) - the most widely used instrument to measure perceived exertion (Chen, Fan & Moe, 2002). The intention of such research has often been to analyze how RPE relates to a variety of physiological and psychological measures (Chen et al., 2002). However, in soccer the overall performance is usually determined by the technical or skill-related abilities of the players (Rampinini, Impellizzeri, Castagnac, Coutts & Wisløff, 2007). This noticeable disparity drove the initiation of this research.

Purpose

This purpose of this thesis is to investigate potential relationships between perceived exertion and sport-specific performance variables. More specifically, focusing on soccer, RPE values will be correlated to a player's pass completion percentage (PC%) in order to explore the potential effect that psychological satisfaction or dissatisfaction of

performance has on the perceived exertion rating a player provides. In addendum, this thesis also intends to use Catapult Sports PlayerLoad™ value to validate the findings between RPE and PC%.

Hypothesis

It is hypothesized that relationship between PC% and RPE values will exhibit a negative correlation. More specifically it is thought that a higher pass completion percentage, indicative of a superior standard of performance, will prompt a decreased perception of workload, demonstrated by lower rating of perceived exertion value.

CHAPTER 2

REVIEW OF LITERATURE

Rate of Perceived Exertion

Perceived exertion is the subjective intensity of effort, strain, discomfort, and/or fatigue that is experienced during physical exercise (Robertson & Noble, 1997). When determined post exercise, this subjective measure is a method to understand an athlete's perspective on the entire exercise session (Kilpatrick et al, 2015).

The most widely used instrument to measure perceived exertion or exercise is the rating of perceived exertion (RPE) scale (Ozkan & Kin-Isler, 2007; Chen, Fan & Moe, 2002). Rate of perceived exertion was pioneered by Borg (1998), who defined it as the degree of heaviness and strain experienced in physical work. This psycho-physical tool (Scherr et al, 2013);

> "Integrates various information, including many signals elicited from the peripheral working muscles and joints, from the central cardiovascular and respiratory functions and from the central nervous system. All these signals, perceptions and experiences are integrated into a configuration or "Gestalt" of perceived exertion" (Borg, 1982).

As demonstrated in Table 2.1 and explained by Borg (1982); "numbers should be anchored by verbal expressions that are simple and understandable by most people". However it is important to note that that the visual design and position of verbal anchors could be influential in determining the athlete's rating (Borg & Kaijser. 2006).

Research has been inconsistent about the ideal time in which to determine RPE. Durations of between 5 and 30 minutes post exercise have been previously recommended (Kilpatrick, Bortzfield & Giblin, 2012; Kraft, Green & Thompson, 2014; Singh, Foster, Tod, McGuigan, 2007) however the 2015 study from Hiscock, Dawson and Peeling identifies "that 15-minute post exercise is a sufficient passage of time for the accurate and reliable reporting".

Scherr et al., (2013) summarizes Borg's RPE scale as "an affordable, practical and valid tool for monitoring and prescribing exercise intensity, independent of gender, age, exercise modality and physical activity level".

Table 2.1 - *Ratings of Perceived Exertion Scale*

Rating	Verbal Anchor
	Rest
1	Very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	
7	Very Hard
8	
9	
10	Maximal

(Adopted from Foster et al., 2001)

Rate of Perceived Exertion & Physiological Variables

The synopsis of previous research suggests that RPE correlates well to many physiological responses (Soriano-Maldonado et al., 2007; Chen et al., 2002; Kilpatrick et al., 2015). Physiological variables that relate to perceptions of effort include metabolic rate, ventilation, blood flow, and muscular fatigue (Borg, 1997; Robertson & Noble,

1997; Kilpatrick et al., 2015). Although, it is suggested by Soriano-Maldonado et al., (2007) and Eston & Williams (1988) that devoting a "familiarization period with the RPE process" can improve the correlation between RPE and physiological variables.

Rate of Perceived Exertion & Psychological Variables

Morgan (1981), Rejeski et al. (1991), Borg (1998) & Chen, Fan & Moe (2002) have identified that the relationship between ratings of perceived exertion and physiological indicators of exercise intensity may be undermined by the presence of potential psychological variables. Select psychological considerations that are linked to exertion include motivation, mood state, arousal, mental stress, pacing, and exercise experience (Kilpatrick et al., 2015).

Conclusively, RPE is correlated with a variety of psychophysiological variables (Kilpatrick et al., 2015). As it is the outcome of complex and dynamic interactions among various stimuli and inputs, RPE is therefore perhaps best considered as a gestalt of many physiological and psychological sensations, rather than a simple summation of varied parts (Borg, 1997). This thesis intends to further explore the complexity of RPE by investigating whether, in addition to physiological and psychological factors, performance variables influence the determination of an RPE rating.

PlayerLoad™

The use of Global Positioning System (GPS) has been revolutionary in the monitoring of player workload (Massa et al., 2013). It has become common for sports

scientists in high level field-based team sports to quantify player movements during competition using GPS technology (Coutts & Duffield, 2008).

PlayerLoad™, a triaxial-accelerometer one-number metric created by Catapult, is a summation of instantaneous change of forward, sideway and vertical accelerations (Massa et al., 2013). In 2014, Barrett, Midgley & Lovell found that PlayerLoad™ had a moderate to high degree of test-retest reliability and demonstrated convergent validity with measures of exercise intensity on an individual basis. Reiterating this, another Barrett et al., (2015) study established that PlayerLoad™ and its individual planes are reliable measures during standardized 90-min soccer match-play simulation. In this study PlayerLoad™ will be used as a value of 'actual workload' and relied upon to determining the accuracy of RPE.

Pass Completion Percentage

Success in soccer matches is heavily reliant on the technical performance and skill proficiency of players (Russell, Rees & Kingsley, 2013; Harper, West, Stevenson, Russell, 2014; Russell, Benton, & Kingsley, 2010). The most popular technical indicator in soccer is ball possession, due to its strong association with success (Bradley, Lago-Penas, Rey, & Diaz, 2013). Individually, in resemblance to ball possession, pass completion percentages can be used as a measure of technical performance.

Unfortunately, limited descriptive data exists to characterize skill-related performances during competitive soccer match play (Russell et al., 2013). However it is known that ball possession can be influenced by match location, quality of opposition and score line (Lago & Martin, 2007).

Pass completion percentage differences could be due to positional roles and responsibilities (Alexander, 2014). In the male French First League findings showed that pass completion percentages for central defensive midfielders, and central attacking midfielders ranged from 75% to 78% with forwards and central defenders averaging only 71% and 63%, respectively (Dellal, Wong, Moalla & Chamari, 2010). In the female game "the central defensive midfielder (CDM) averaged the highest pass completion percentage" and "the central defender had a statistically lower pass completion percentage compared with the central attacking midfielder, central defensive midfielder, and wide midfielder" (Alexander, 2014).

Pass completion percentages can also be influences by workload, Alexander (2014) found "statistically significant relationships between distance covered in high-speed velocity bands and pass completion percentage". Alexander went on to summarize that based on his analysis; relationships indicate that a player with a greater workload is going to be more successful within a game (Alexander, 2014).

The significant influence of these variables is understood however for this investigation, pass completion percentages will be considered 'one-dimensional' with the simple notion that a higher percentage indicates a superior performance. This will allow a fundamental relationship between perceived exertion and performance variables to be examined.

CHAPTER 3

METHODS

Subject & Game Selection

This thesis focused on five women's soccer players from a single NCAA Division I institution that participated in the Southern Conference during the 2014 fall season. The sample included athletes from the four outfield positions: central defender (CD, n=1), fullback (FB, n=1), central defensive midfield players (CDM, n=2), and a central attacking midfielder player (CAM, n=1). Additionally the subjects ranged in university class: freshman (Fr., n=1), sophomore (So., n=1), junior (Jr., n=1), and seniors (Sn. n=2).

A total of four conference and conference tournament games were included in analysis. To ensure a comprehensive analysis games were included irrelevant of the result (win, loss or tie) or the location (home or away games). Games were excluded if they went to overtime or if video footage was of insufficient quality to accurately analyze.

The combined inclusion criteria ensured players participated in the full 90 minutes of game time in a single position in all games selected. Additional requirements for inclusion were the utilization of a Catapult Minimax S4 GPS device (miniMax-10 Hz, Catapult Innovations, Melbourne, Australia) for the duration of the match, and the provision of a post-game RPE using the modified Borg scale (0-10).

Data Collection

Five (n = 5) women's soccer players were analyzed for four matches during 2014 conference play, creating a total sample size of twenty (20) data points. Existing rate of perceived exertion (RPE) and Catapult PlayerLoad™ (PL) values for each individual in each game were gathered from an existing athlete-monitoring database and analyzed

retrospectively. When collected, the RPE scale was presented to the athlete meaning they had visual contact with the scale and verbal anchors. Also all values were collected between 10 and 30 minutes post exercise following post game formalities and cool down (Kilpatrick, Bortzfield & Giblin, 2012; Kraft Green & Thompson, 2014; Singh, Foster, Tod, McGuigan, 2007; Hiscock, Dawson & Peeling, 2015). The GPS devices were removed from the player's possession at a similar time however the data was retrospectively analysed so that the PL value was solitarily comprised of actual playing time.

Video footage from the four conference games was analyzed in detail by the lead investigator; complete passes, incomplete passes, and total numbers of attempted passes were recorded. These three statistics were then used to calculate a pass completion percentage (PC%) for each individual in each game. A pass was identified if the subject was deemed to intentionally target a teammate to transfer the ball to. In order for the pass to be considered complete, the supposed target must have had the opportunity to gain undisputed control of the soccer ball upon reception of the pass. Passes were deemed to be incomplete if the pass failed to reach it's intended target, this includes; misdirected passes, interceptions and if the target had to compete for clear possession of the ball with an opponent during immediate reception of the pass.

Data Analysis

Rate of perceived exertion and PL values were separately compared to PC%. A Pearson product-moment correlation coefficient (r) was calculated as a numerical measure of linear correlation. The coefficient of determination (R^2) was then calculated

to demonstrate the accuracy of perceived workload (RPE) in comparison to actual workload (PL) values.

CHAPTER 4

RESULTS

The Pearson product-moment correlation coefficient (r) between PC% and RPE was found to be 0.028. For PC% and PL the relationship showed a 0.50 correlation. The coefficient of determination (R^2), demonstrating the proportion of variance of perceived workload (RPE) in comparison to actual workload (PL), were calculated to be R^2=0.00077 and R^2=0.2502 respectively (Table 4.1).

Table 4.1. Overview of Results

Components	Statistic	Value
PC% & RPE	r	0.027796216
PC% & PL	r	0.500202604
PC% & RPE	R^2	0.00077
PC% & PL	R^2	0.2502

Figure 4.1. Pass Completion Percentage vs. RPE

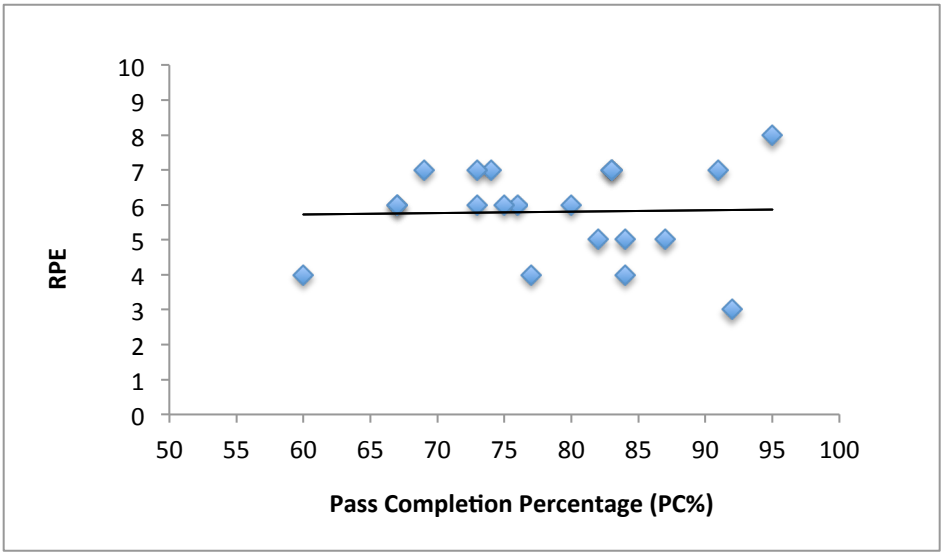
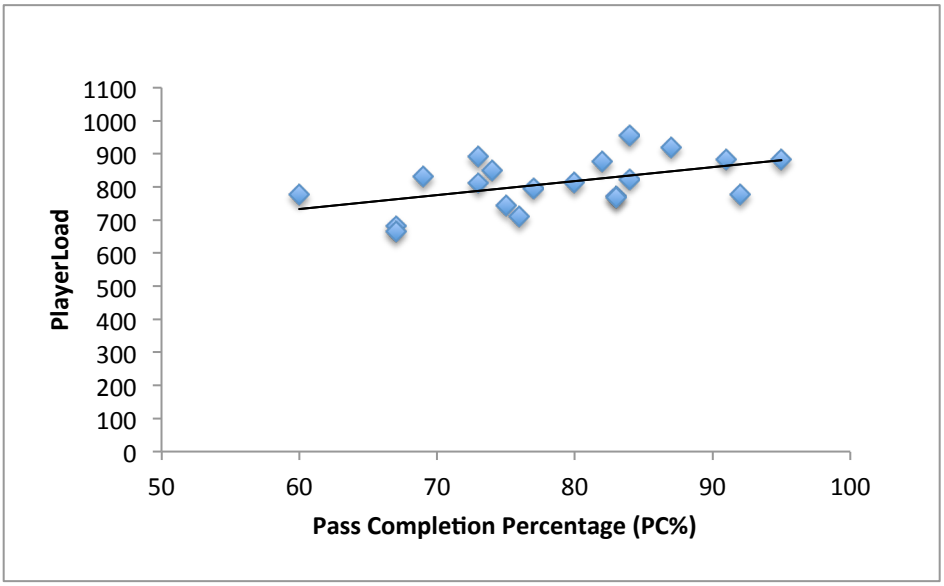


Figure 4.2. *Pass Completion Percentage vs. PlayerLoad™*



The Pearson product-moment correlation coefficient (r) between pass completion Percentage and PL was found to be considerably stronger than that of the PC% and RPE variables. According Hopkins (2002) the correlation relationships can be descriptively classified as moderate-large and trivial respectively. Also, as shown in figures 4.1 & 4.2, the R^2 value representing the PC% & PL relationship is less varied and more predictable that the PC% & RPE relationship. This demonstrates that PL is more a reliable measure of workload compared to that of RPE.

CHAPTER 5

DISCUSSION

Summary of Results

This study aimed to explore the relationship between RPE and Pass Completion Percentage (PC%), with the hypothesis that a linear negative relationship would be found. Unexpectedly, only a trivial relationship ($r = 0.028$) between the two variables was established. In comparison a moderate-large r value of 0.50 was found between PlayerLoad™ (PL) and PC%. The PL and PC% variables also demonstrated a more reliable relationship, through coefficient determination, compared to the relationship of RPE and PC%.

The moderate-large relationship ($r = 0.50$) found between PC% and PL values demonstrates that there is a positive relationship between workload and performance variables. Alexander established a similar relationship; he found statistically significant relationships ($r = 0.69$) between distance covered in high-speed velocity bands and pass completion percentage (Alexander, 2014). The finding from this study supports the conclusion that a player with a greater workload is going to be more successful within a game (Alexander, 2014).

The insignificant and slightly positive r-value evidently negates the proposed hypothesis. However with the knowledge that RPE correlates well to physiological workload (Soriano-Maldonado et al., 2007; Chen et al., 2002; Kilpatrick et al., 2015) and using the novel correlation between PL and PC% to demonstrate the relationship of actual workload and performance variables; the trivial correlation and decreased coefficient determination value found between RPE and PC% ($r = 0.028$ & $R^2 = 0.00077$

respectively) infers that perceived exertion is somehow manipulated by performance variables. Further research is undoubtedly required to enhance and confirm this initial conclusion, however this finding is significant in developing the understanding of perceived exertion values. These findings ultimately suggest that not only is RPE correlated with a variety of psychophysiological variables (Kilpatrick et al., 2015) but that it is also affected by performance variables.

Future Research

As a preliminary investigation this thesis has provoked many recommendations for further research. Firstly, the fundamental deficiency of this study was the limited sample size. By increasing the number of subjects, any correlations or relationships found would have been emphasized. Relatedly, although this study comprised of a variety of playing positions and university classes, the demographics of the sample population could be further increased. By including a more comprehensive sample of soccer players, the validity and applicability of the findings would improve.

Furthermore, for this investigation pass completion was intentionally considered percentages as 'one-dimensional' variables, with the simple notion that a higher percentage indicates a superior performance. In future research the many influential components of pass completion percentages, such as playing positions, responsibilities, match location, quality of opposition and score line (Alexander, 2014; Lago & Martin, 2007) should be considered to allow for better comprehension and applicability of findings.

It is also suggested that the relationships between performance variables and perceived exertion ratings are investigated in other sports. This again would enhance comprehension, develop validity, and enhance applicability of RPE as a monitoring tool.

CHAPTER 6

CONCLUSION

Post-exercise rate of perceived exertion (RPE), a subjective measure of effort, discomfort and/or fatigue that accompanies physical exercise (Cite Robertson & Noble, 1997 here), is considered as a gestalt of many physiological and psychological sensations (Borg, 1997). This purpose of this thesis was to further explore the complexity of RPE by investigating whether, in addition to physiological and psychological factors, performance variables influence the determination of an RPE rating. More specifically it was hypothesized that a higher pass completion percentage would elicit a decreased RPE value.

Rate of perceived exertion (RPE) values, Catapult Playerload™ (PL) data and pass completion percentages (PC%) were collected and correlated. Analysis determined a trivial correlation coefficient (r) of 0.028 for RPE and PC%, whereas the PC% and PL relationship demonstrated a moderate-large 0.50 correlation. Furthermore, the PL and PC% variables established a more reliable relationship.

These results negate the original hypothesis of a negative correlation between RPE and PC%. However, the analysis does indicate that RPE may be influenced by performance variables. Although the novel findings of this study do substantiate the multifaceted nature of perceived exertion values, further research is required to improve validity and applicability of this conclusion.

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