Chapter IV

Results:

Differences in intensity between matches and training

Figure 1 illustrates the distance per minute values for each position in both matches and training. The statistical analysis suggested that there was no significant interaction effect between distance covered per minute between training or match performance by position (P = 0.57).

The statistical analysis also showed a significant main effect for match or training (P = 0.03), with a mean of 98.38 ± 8.07 $m.min^{-1}$ covered in matches, and 94.00 ± 14.61 $m.min^{-1}$ covered in training. Moreover, there was also a significant main effect found for playing position (P = 0.01), with defenders covering significantly less distance per minute than midfielders (-8.43$m.min^{-1}$; P = <0.01) or forwards (-7.33$m.min^{-1}$; P = 0.02). There were no significant differences between distances cover per minute between midfield and forward players.

Figure 2 presents the high-speed distance per minute values for each position in both matches and training. A significant interaction effect between high-speed distance by position is shown (P = 0.03)

For match or training a significant difference was also shown (P = <0.01) with a mean of 573.31 ± 109.63m covered in matches, and 238.92 ± 69.67m covered in training. Furthermore, there was also a significant main effect found for playing position (P = 0.01) with midfielders covering significantly more high-speed distance than defenders (100.32m, P = 0.04) and forwards

(117.07m, P = 0.01). There was no significant difference between the high-speed distance covered by defenders and forwards.

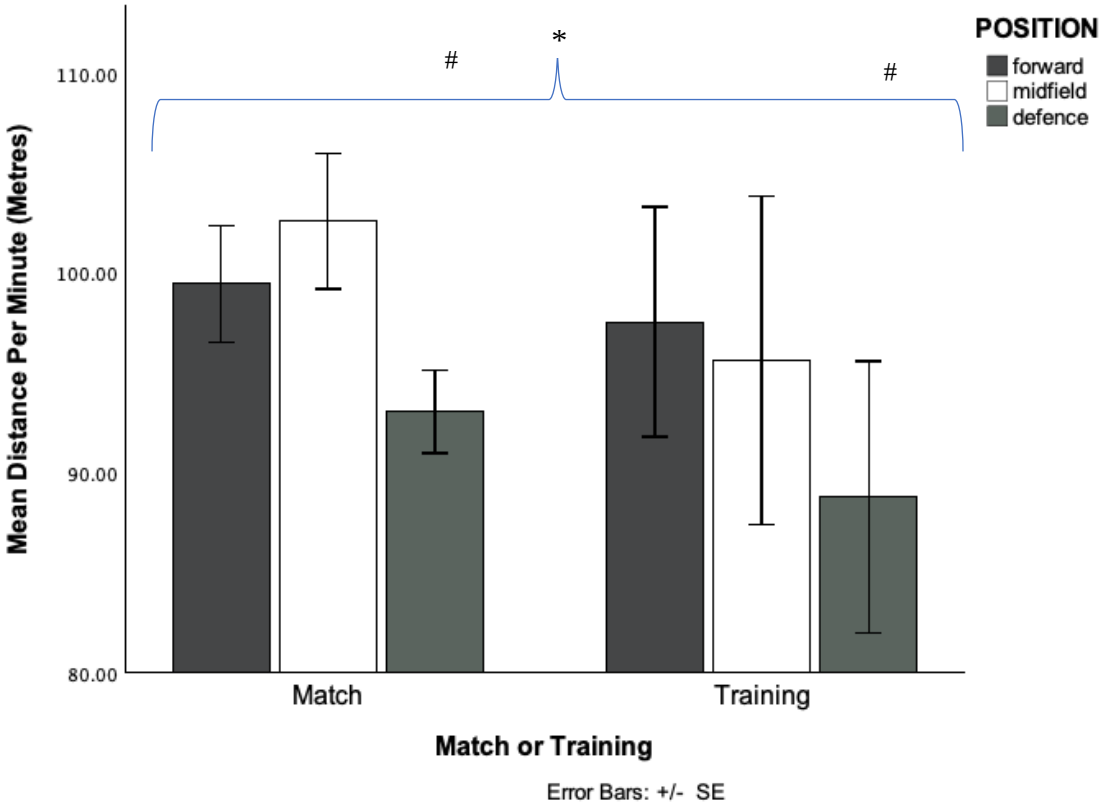

*Figure 1: Mean Value for Distance per Minute ± Standard Error for Forward, Midfield and Defence during matches and training. * Significant difference between match and training regardless of position (P = 0.03). # Significantly less distance per minute covered for defenders than midfield and forward players (P = 0.01).*

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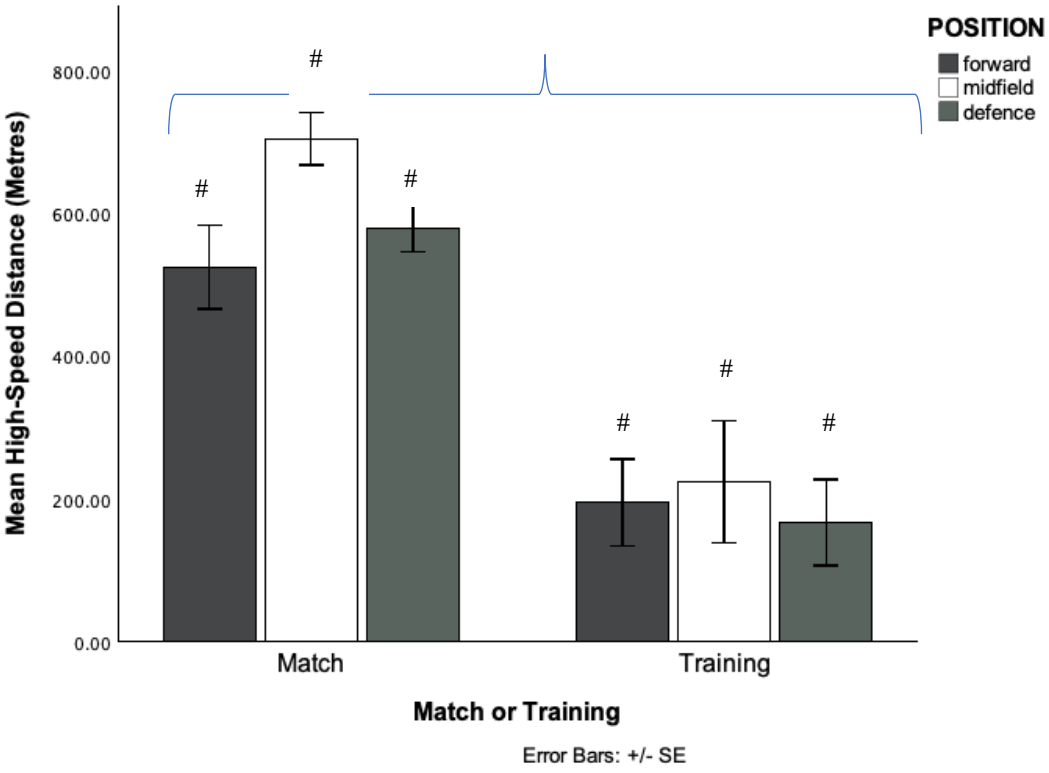

*Figure 2: Mean Value for High-Speed Distance ± Standard Error for Forward, Midfield and Defence during matches and training. # Significant difference between match and training when regarding positions (P = 0.03). * Significant difference between match and training disregarding position (P =< 0.01). 0.01 = significantly more high-speed distance covered by midfielder players than defenders and forwards.*

Relationship between Distance Per Minute and xG

Figure 3 presents the relationship between total mean distance per minute aggregated across all playing positions and the metric of expected goals. As can be seen from the figure, there is no significant correlation between the total distance per minute mean and expected goals (R^2 = 8.32; P = 0.97).

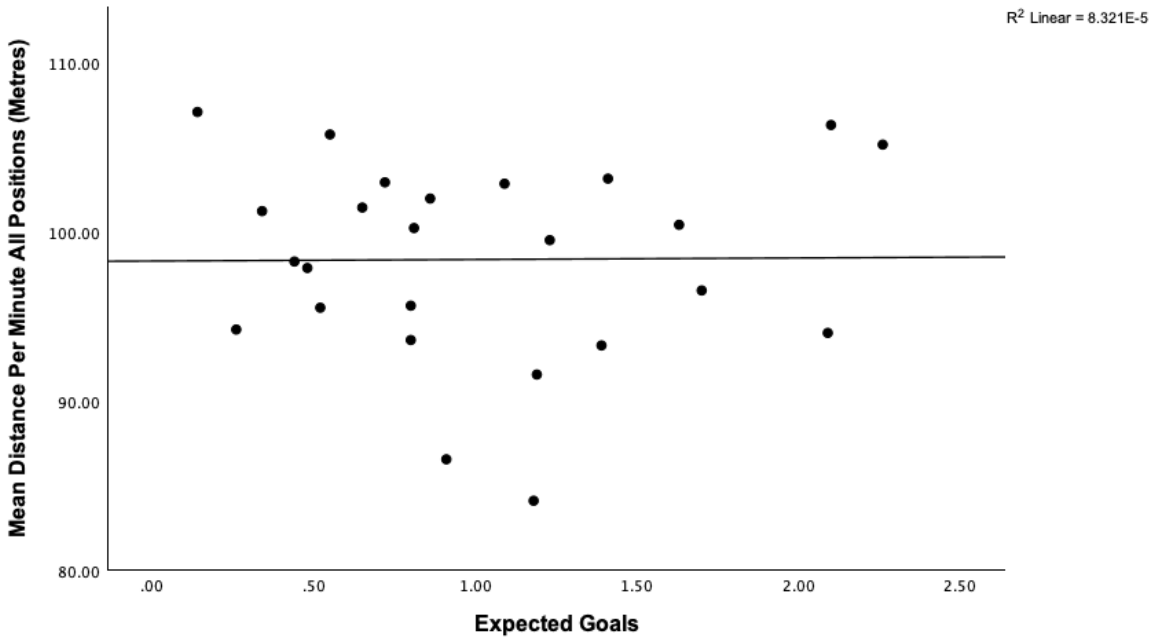

Figure 3: Mean Value for Distance Per Minute of All Positions aggregated and xG of the team from each match.

Figures 4 - 6 illustrate the relationship between the mean distance per minute of forwards, midfielders, and defenders, respectively, with expected goals. Each position shows no significant correlation between distance per minute and expected goals (Forwards: $R^2 = 0.013$ P = 0.59, Midfielders: $R^2 = 0.02$ P = 0.51, Defenders: $R^2 = 0.001$ P = 0.88).

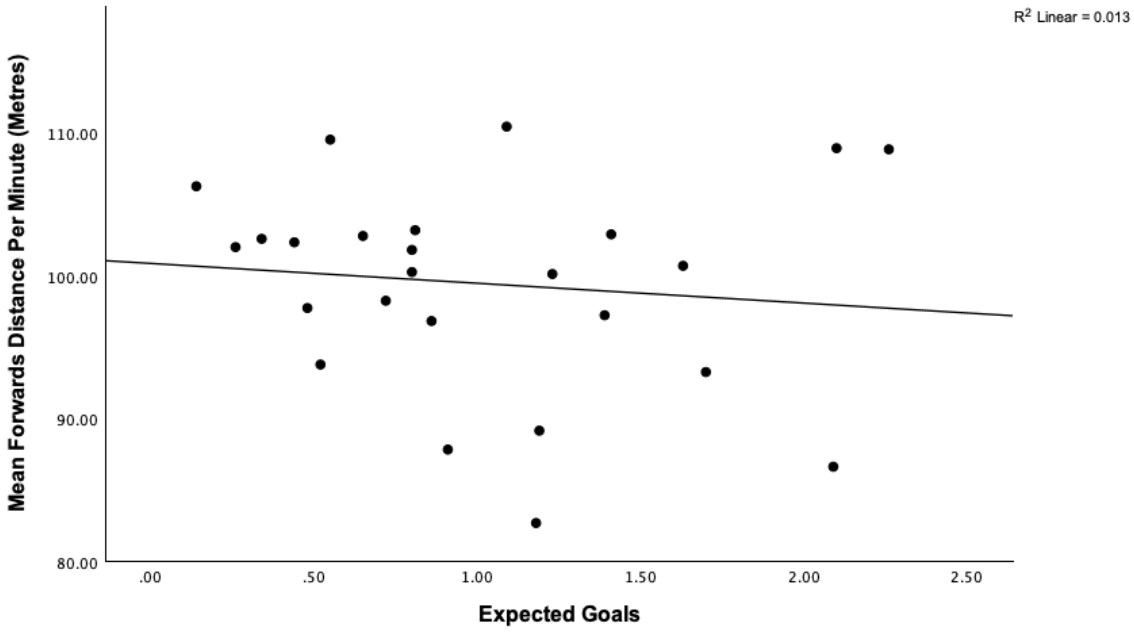

Figure 4: Mean Value for Distance Per Minute of Forwards and xG of the team from each match.

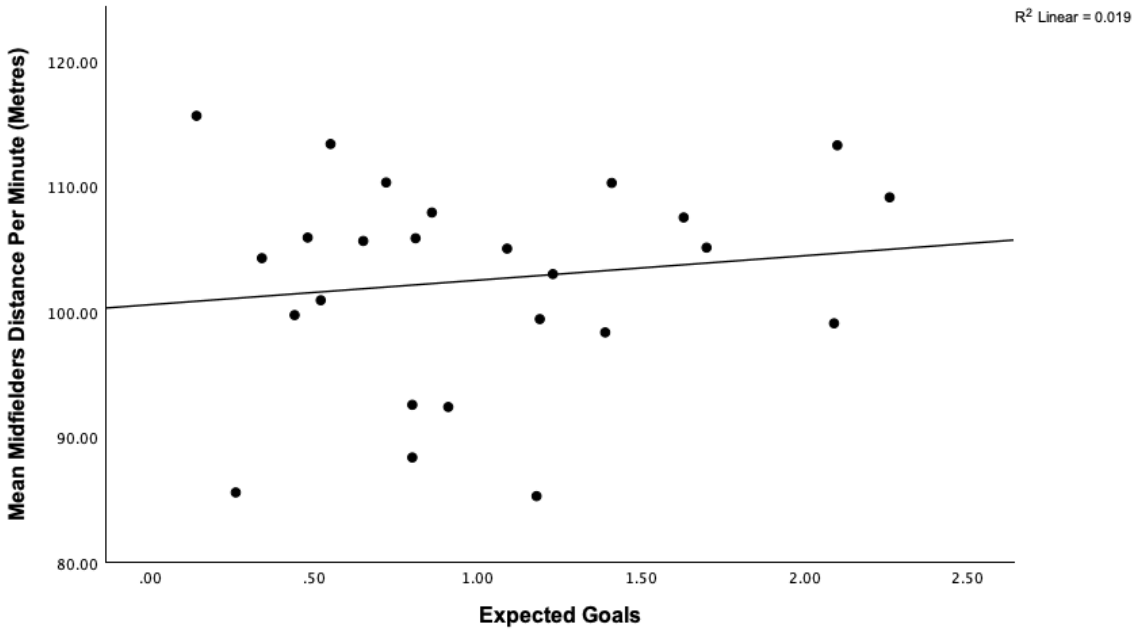

Figure 5: Mean Value for Distance Per Minute of Midfielders and xG of the team from each match.

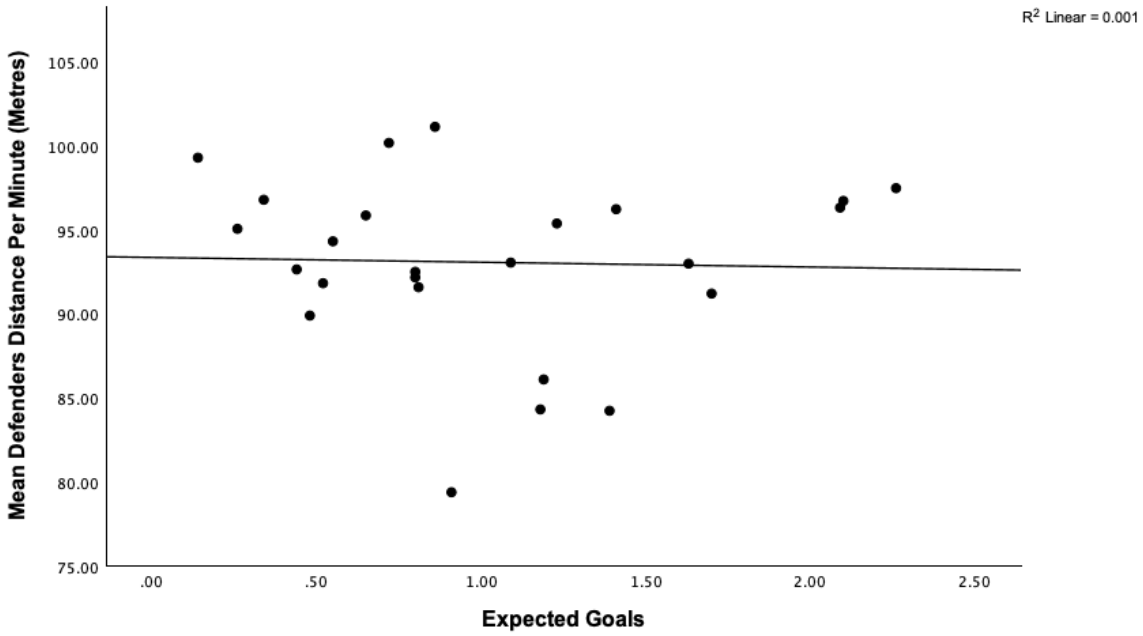

Figure 6: Mean Value for Distance Per Minute of Defenders and xG of the team from each match.

Relationship between High-Speed Distance and xG

Figures 7 – 9 illustrate the relationship between high-speed distance and xG. No statistically significant relationships were found whether all positions (R^2 = 0.02 P = 0.48), forwards (R^2 = 0.04 P = 0.35), or defenders (R^2 = 0.03 P = 0.41) were considered. However, as shown in figure 10, a significant weak relationship was found between high-speed distance and expected goals for midfielder players (R^2 = 0.34 P < 0.01).

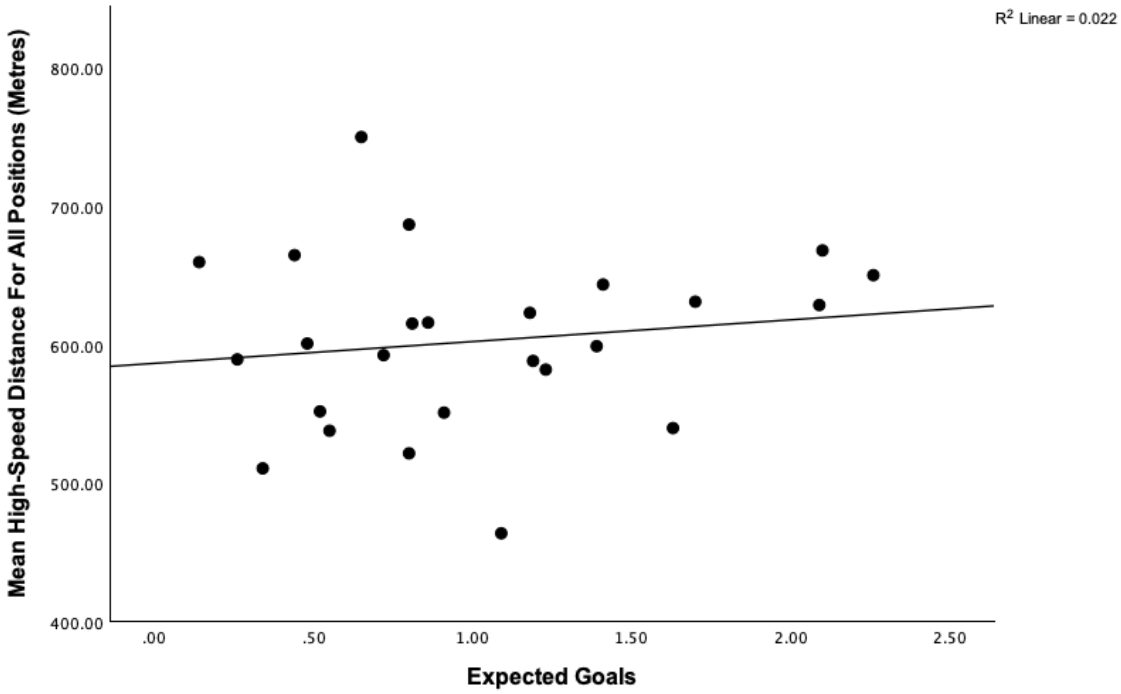

Figure 7: Mean Value for High-Speed Distance of All Positions aggregated and xG of the team from each match.

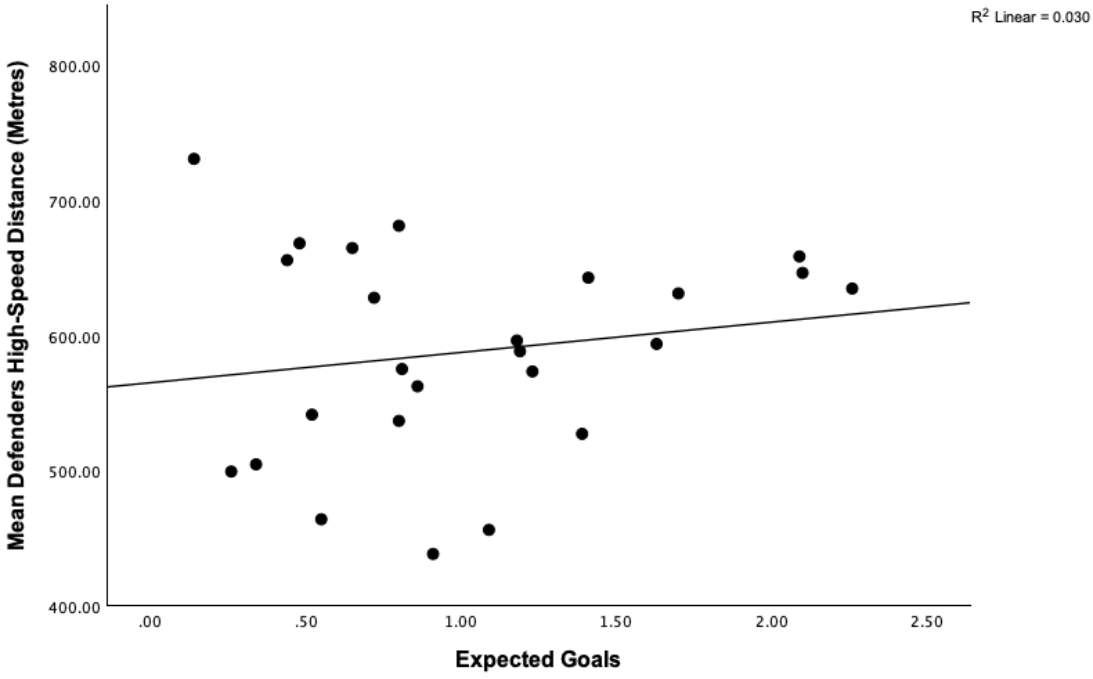

Figure 8: Mean Value for High-Speed Distance of Defenders and xG of the team from each match.

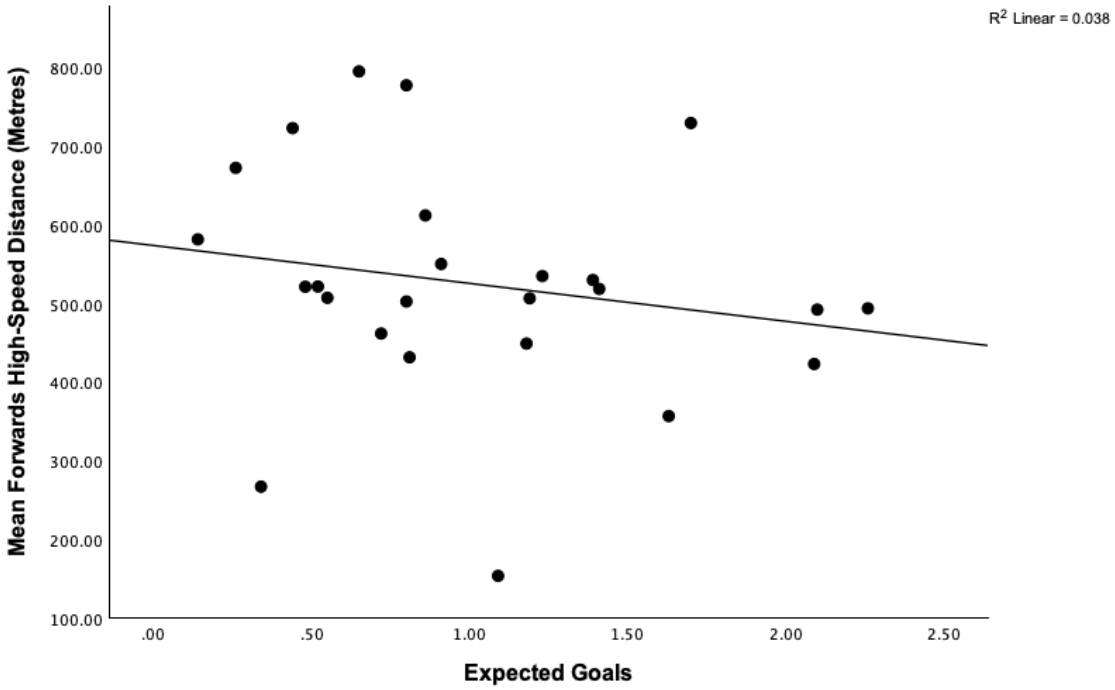

Figure 9: Mean Value for High-Speed Distance of Forwards and xG of the team from each match.

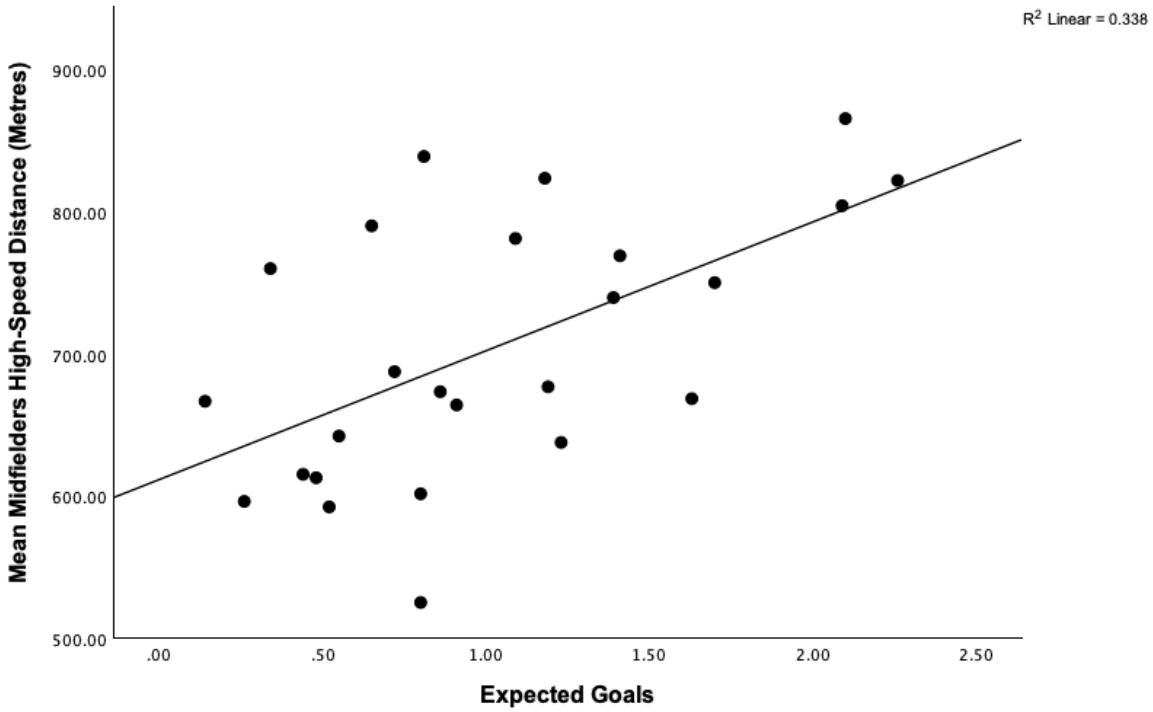

Figure 10: Mean Value for High-Speed Distance of Midfielders and xG of the team from each match. 0.01 = significantly more xG with an increased midfielder distance per minute. R^2 = 0.34 a weak correlation between xG and midfielder distance per minute.

Chapter V

Discussion:

The present study demonstrates that there is no significant difference between distance per minute covered by players of various positions in competitive football matches, and distance per minute covered in training using medium- and large-sided games when analysing player-specific data. This supports that the intensity of the drills conducted during training were at a similar intensity to what is required in a competitive match, when comparing the two conditions on a positional basis. Therefore, in the present study, the null hypothesis of the first research question has been accepted, and the alternative hypothesis has been rejected.

There were however significant differences found in distance per minute between different player positions, irrespective of being in the match or training conditions. The data illustrated that defenders cover significantly less distance per minute than both forwards and midfielders.

Moreover, more distance per minute was covered in matches than training, if positional role was not considered within the analysis.

Furthermore, a significant difference was found between the high-speed distance covered during training compared to high-speed distance covered in a match suggesting that the medium- and large-sided games in training do no replicate match demands of high-speed distance.

In relation to the second research question, there was no relationship found between distance per minute and expected goals for any playing positions; forwards, midfielders, defenders, or when positions were aggregated. Moreover, there was no significant relationship found between high-speed distance and expected goals for forwards, defenders, or when positions were aggregated, however a significant positive correlation between these two factors was seen in midfielders. As the high-speed distance value increased for midfielders, the expected goals value for the team also increased. Nonetheless, the majority of data gathered analysing the relationship between running intensities during matches and the impact on expected goals scored by the team was not significant, consequently resulting in the alternative hypothesis being rejected, and the null hypothesis being accepted.

In sum, this would suggest there to be no improvement in expected goals by the team when increasing either their high-speed distance, nor their distance per minute covered. It is worth noting the significant positive correlation outlined above seen in the midfielder position, however this does not change the failure to reject the null hypothesis, as when the full team's data was aggregated, there was no significant improvement in expected goals value.

Key findings and application to context

As illustrated in Figure 1, there was no interaction effect (P = 0.57) between distance per minute during training when compared to distance per minute

during matches, supporting that medium- and large-sided games in training allow for similar distances per minute to be covered as in competitive football matches, by position. As discussed in the literature review, there has not been a substantial amount of in-depth research comparing distance per minute in training and matches. Therefore, the application of the findings of the present study, a non-significant difference between distance per minute in training and matches, helps to support the use of medium- and large-sided training drills as an effective training tool for match preparation, as these drills effectively replicate games intensity.

Figure 2 illustrates that high-speed distance is significantly different during matches and training ($P = <0.01$). This finding is supported by research from Anderson et al. (2016), who identified that around 100m of high-speed distance was collated during training compared to a 900m average during matches. This finding means that high-speed distance in medium- and large-sided games do not produce similar values to the demands required within competitive matches. Therefore, the completion of medium- and large-sided training drills should not be used to replicate the absolute demands of the high-speed distance required during a competitive football match, as training high-speed distance value do not achieve similar value as match high-speed distance.

The results of this could be explained by the fact that high-speed distance was not relative data, but absolute data. Therefore, it is expected that shorter training drills in comparison to 90-minute matches will result in lower values

of high-speed distance if the duration of a training drill is not considered. Future research on high-speed distance in relation to the similarity between training and match high-speed distance values, should measure high-speed distance relative to match data, to aid in understanding the use of medium- and large-sided training drills when preparing for competitive match demands. For instance, comparing a 15-minute training drills to 15-minute segments of a competitive match.

When aggregating the data of all playing positions, a significantly lower distance per minute and high-speed distance were found in training when comparing to matches. There was a significantly less distance per minute covered in training than there was in matches ($P = 0.03$), and significantly less high-speed distance covered in training than in matches ($P = <0.01$). This indicates that if positional role is not taken into account when analysing the data, the results suggest that running intensities do not replicate match demands. This finding supports previous research by Oliva-Lozano et al. (2022), who found that intensity outputs including high-speed distance running, were significantly higher in matchday data than in all the training data, when playing position is not accounted for ($P = <0.01$). These findings together, suggest that when player position is not accounted for, research suggests there is a difference between match and training intensity, but that there are not significant differences in the intensity of the positional demands. However, more extensive research on distance per minute as a variable, and its similarity in training and match data, is required to form a conclusion.

Significant differences in matches and training data were also found between the positions, for distance per minute (P = 0.01) and high-speed distance (P = 0.01). Defenders covered significantly less distance per minute than forwards and midfielders (P = 0.01). This is supported, in parts, by previous research from Abbott et al. (2018), who also found that central defenders covered the lowest values in all metrics (P = <0.01). However, it is interesting to note that Abbott et al. (2018) found wide defenders ('wing-backs'), who are required to complete over- and underlaps at a high intensity on the wide, less compacted areas of the pitch (Abbott et al, 2018), have some of the highest intensity values measured, both in high-speed running and sprinting. This suggests that tactical and formation decisions made by football managers can substantially affect GPS metrics, such as distance per minute, or high-speed distance covered, because different positions are required to perform different tasks depending on what they have tactically been requested to do by coaching staff. Therefore, future research should incorporate tactical information into the analysis of player data when comparing match and training values, to support forming conclusions on whether training running intensities are similar to competitive match running intensities.

Figures 3-6 illustrate the relationship between distance per minute and expected goals by the team in the present study. There were no significant correlations between distance per minute of any of the three measured playing positions (Forwards: P = 0.59, Midfielders: P = 0.51, Defenders: P = 0.88) or the aggregated value of the three playing positions (P = 0.97), and

the expected goals of the team. This finding is contradicted by the research of Chmura (2018), who found that increasing physical metrics such as total distance covered could lead to improved performance outcome. Chmura (2018) found that midfielders and forwards completed significantly higher total distance in games that were won, than in games that were lost ($p = <0.05$). An explanation for the non-significant findings in the present study, could be whether the distance per minute covered was completed in or out of possession of the ball. Clemente et al (2013) separated distance per minute covered whilst in and out of possession and found that possession of the ball increased for teams that progressed further in the competition, implying that if in this present study ball possession was considered, differences to performance outcome may occur. For instance, if a greater distance per minute was covered while in possession expected goals may increase. Overall, this analysis to implies that an increased distance per minute does not lead to an improvement in the outcome of expected goals, instead, this could be the result of other factors that can affect performance, such as the technical and tactical of player position, player performance and ball possession (Liu et al, 2021). Liu et al. (2021) also considers contextual factors that can affect the outcome of matches, for instance match location (home or away), opponent strength and team strength. This suggests that distance per minute is not the most influential factor to increasing goals scored in a football match, however other existing studies such as Clemente et al. (2013) and Chmura (2018), have identified other measures which correlate with performance outcomes. These include increased distance per minute while in possession significantly correlating with tournament

progression (Clemente et al, 2013), and total distance covered significantly correlating with a winning match outcome (Chmura, 2018), which may explain why in the present study, distance per minute and expected goals have not correlated. Therefore, in future research, the inclusion of more external variables that can impact physical metrics on performance outcome, such as match location, ball possession and opponent strength, should be included to identify which influences on the outcomes are consistently significant.

As seen in Figures 7 to 9, there was no significant relationship between high-speed distance in all playing positions (P = 0.48), forwards (P = 0.35), or defenders (P = 0.41), and expected goals by the team. This suggests that the number of expected goals does not increase with high-speed distance covered of all playing positions, forwards, or defenders. However, when analysing the impact of midfielders high-speed distance on expected goals of the team in isolation, a significant difference was found (P =< 0.01). The present study suggests that midfielders' high-speed distance directly correlates with the expected goals of the team. This finding supports the research of Rhodes et al. (2021), Chmura et al. (2018), who both found an increase of high intensity actions to positively impact the outcome of games and Llana et al (2022) who specifically identified that when some players increased high-speed distance the impact on expected goals value increased. However, despite this significant difference in the present study, the data has an R^2 value of 0.34, suggesting that although the correlation is significant, it is weak. An alternative explanation for the significant correlation

of the present study, may be that midfielders tend to cover significantly more distance per minute whilst in possession of the ball, than forwards and defenders (Clemente et al, 2013). This suggests that possession of the ball may correlate with expected goals, and that future research should explore the impact of running intensities in and out of possession of the ball, on performance outcome.

In sum, further research is required to further explore the potential application to football, as although the present study suggests it is possible an increased high-speed distance by midfielders could improve expected goals by the team, it cannot be relied on at this stage by managers to implement strategies based on this finding alone, as other factors may be at play.

Limitations

The foundations of the present study provide a valid rationale for future developments to uncover the impact of running intensities on performance outcomes and whether training running intensities replicate the demands of match training intensities. Nonetheless, the present study did have some methodological limitations. For instance, due to this investigation being conducted during a professional football clubs' season, the study had to be an observational field study. In this investigation, there is no direct manipulation of the variables by the researcher. Therefore, many factors of the investigation were not controlled, such as the sample size of training

sessions, which participants were included in specific training drills and matches, and which participants' data was able to be included in the study. Moreover, the coaching staff may have made tactical decisions to implement different strategies and styles of training and gameplay, which directly influenced the distance per minute or high-speed distance covered in any given period. For example, Ju et al. (2022) identified that increased high-speed distance outputs are exerted by players required to 'break into the box' and 'run in behind'. This proposes a potential limitation of positional categories in the present study, as players who play similar positions may be instructed to complete different tactical actions which elicit either more or less running intensity values. Overall, a substantial methodological limitation of the present study was the lack of control of variables by the researcher, reducing the reliability.

Another limitation of the present study, may be that the groups studied, could have been further subdivided to allow for more exploration. Abbott et al. (2018) found that 'wide defenders' produced some of the highest high intensity running values ($P < 0.01$), whilst 'central defenders' produced the lowest values in all categories investigated ($P < 0.01$). As the present study considered 'defenders' as one group, the output of high-intensity actions were not investigated by sub-position. In future research on the differences between positions, it is worth increasing the number of groups to allow for more specific analysis.

The present study also did not take into account the sizes of the pitches that the medium- and large-sided games were completed on, only the minimum size a pitch must be to be considered medium- or large-sided. This could be considered a limitation, as the size of the pitch and number of players included in each drill may have differed between training data collections, whilst these variables in the matches would have been mostly consistent. Therefore, although the findings of the present study aligned with that of Owen et al (2013), who found that in medium- and large-sided games, a larger output of high intensity running and high-speed running were seen, due to this limitation, the present study should adapt methodology to encompass pitch size, as Owen et al (2013) found highest reproducibility when specifically identifying pitch sizes. In future studies, maintaining consistency in the size of pitch each medium- and large-sided game was completed on, and the number of players involved, would allow a more in-depth view of what differences in high-speed distance and distance per minute in the training drills elicits. In addition, due to the nature of an observational field study, the timings of each training drill were not controlled in the present study. Therefore, as suggested previously, in future research, the duration of each training drill should be manipulated and controlled to identify differences in physical outputs, such as distance per minute and high-speed distance metrics.

Future research

Along with the required adaptations to research identified throughout, additional research on the relationship between running intensities in training and matches, and the performance outcomes in professional, competitive football matches is needed to quantify the results of the present study.

A potentially influential factor not explored in the present study, as noted earlier, is ball possession held by the team during the match. Lorenzo-Martinez et al. (2021) identified that ball possession has a significant effect on the physical metrics during a game, finding that ‘very high possession teams’ covered less metres per minute than teams of any other level of possession. Another interesting factor explored by Wass et al. (2020) in similar research, was ball-in play time, which was not considered in the present study. Their research found that when ball-in play time decreased, whole match metrics such also significantly decreased ($P < 0.05$). In future studies, collecting data on additional metrics such as ball possession and ball-in play time could provide the data to further explain the impact that running intensity such as distance per minute and high-speed distance can have on performance outcomes like expected goals.

An interesting idea for future research could be applying the improved methodology of the present study to different levels of competition and ability, to identify the impact of running intensities on performance at both amateur, lower level professional, and elite levels of football. A study by Bangsbo (2014) found differences in the physical output, such as high-speed running and high intensity high-speed runs at different competition levels.

Conducting such research will help to further validate, or invalidate, whether the metrics used in the present study can improve the performance of football teams at different levels.

Chapter VI

Conclusion:

To conclude, this study found that medium- and large-sided games in training are suitable to replicate distance per minute intensities when considered on a positional basis. This conclusion is supported by the non-significant finding (P = 0.57) when analysing the relationship of distance per minute considering position and matches or training. However, this was not the case for high-speed distance.

No significant relationships were found between running intensity, measured either by distance per minute or high-speed distance, and expected goals, other than a weak correlation for midfield players. This suggests that running intensity does not appear to improve the performance outcome of a football team, however more research is required to support this, or an alternative, conclusion.

Adaptations to the methodologies of the present study and ideas for future studies discussed advocate for more research to be conducted to provide greater understanding of the relationship between running intensities in training and in matches, and the impact this may have on performance outcomes. This is essential, to allow for better informed decisions to be made by coaching staff to best prepare their players for the demands of a football match, and to identify if performance can be improved, and ultimately increase the likelihood of a positive match outcome.

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