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Time-on-field distribution of soccer squads in the German U17 and U19 Bundesliga

Introduction

German youth soccer is currently undergoing a phase of fundamental reform. Besides changes in the game's format in children's soccer, the U17 and U19 Bundesliga leagues were replaced by national youth leagues starting with the 2024/2025 season. In this model, teams from clubs with a youth academy cannot be relegated. In addition, the number of possible substitutions per match was increased from five to seven to give more players time on the field (ToF). The reform is intended to ensure better individual player development (Deutscher Fußball-Bund e. V., 2023). It aims at a specific dilemma of talent promotion in youth academies: the conflict between striving for the largest possible immediate competitive success in the running season and the optimum long-term development of all talents.

This long-term perspective has been an essential pillar in talent research since the concept of talent identification and development (TID) was promoted at the end of the last century (Abbott et al., 2005; more recently: Baker et al., 2017). This position, in turn, is based on the concept of expertise research that was developed in the 1990s (Ericsson & Smith, 1991; Ericsson et al., 1993). A central issue in developing expertise—besides the 10-year rule stating that the "road to excellence" requires sustained engagement—is deliberate practice (see Baker et al., 2020, for a recent review). Deliberate practice is conceptualized as extensive domain-specific training with specific properties such as appropriate motivation, access to relevant resources, and optimized training effort.

Interestingly, participating in competitions (demanding for ToF) was not recognized as deliberate practice in the initial publications by some sports psychologists (Ericsson et al., 1993), since this was not seen as purposefully designed to improve specific aspects of performance. This view has since evolved (Baker & Young, 2014), as experiences in sports competitions have been identified as indispensable for reaching top levels in team sports (Janelle & Hillman, 2003). Especially in team sports like football, deliberate practice is generally extended to training and play-like activities such as games in training and competitive matches (Ford & Williams, 2012). Nevertheless, ToF has rarely been addressed as an environmental aspect of talent development in the framework of expertise research. At best, high-performing "peers to compete" are mentioned as an aspect of a most supportive environment (Baker et al., 2020, p. 564).

From the soccer clubs' perspective, two competing strategies emerge in talent promotion: the preference for immediate success and the pursuit of long-term goals of talent promotion (Augste & Lames, 2011). We conceptualize the first strategy as one end of a continuum, which we refer to as the "short-term competitive success strategy" (ST-CSS). At the opposite end of this continuum are clubs primarily interested in developing each player the best possible way, which we term the "long-term talent development strategy" (LT-TDS). Our study approach is based on the assumption that the distribution of ToF may serve as an indicator of the club's strategy. Consequently, concentrating ToF primarily among the most competitive players suggests that the club prioritizes assembling a strong team for immediate success in competition, reflecting an ST-CSS. Conversely, clubs following the LT-TDS would aim to distribute the available team's competition time as evenly as possible across each squad member, recognizing ToF as a crucial stimulus for player development. To the best of our knowledge, there has been no empirical research concerning club strategies for distributing ToF among squad members.

This study pursues three aims: The first is a methodological aim and consists of developing parameters of the ToF distributions in the squads of elite youth teams characterizing more concentrated distributions (indicating an ST-CSS) or more evenly distributed ones (standing for an LT-TDS). These parameters should express a domain-specific characterization of the ToF distributions and go beyond "simple" statistics of dispersion. Second, it investigates ToF distributions in a large representative sample of youth squads, providing a descriptive overview of the most essential characteristics of ToF distributions. After this, two specifically designed sub-studies investigate additional questions of interest. The relationship between success in the leagues and ToF distribution (sub-study 1) examines whether a higher concentration of ToF is indeed associated with higher success, and sub-study 2 aims to find out whether pursuing ST-CSS or LT-TDS is a property typical of specific clubs.

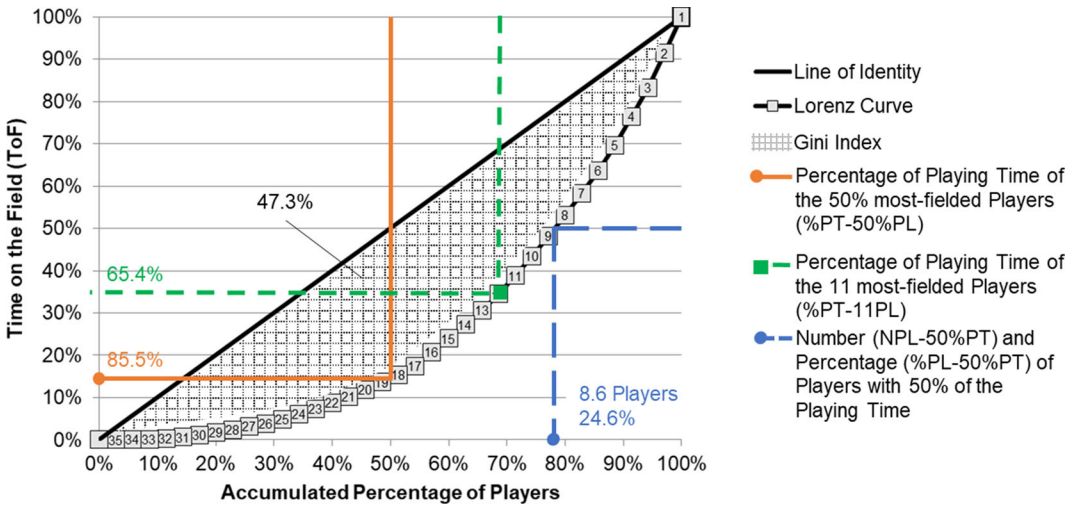

Fig. 1 ◀ Illustration of the study variables representing the ToF distribution of the FC Bayern Munich U19 team from the 2018/2019 season

Methods

Sample and procedures

The raw data for the study were obtained from the website transfermarkt.de. This portal contains a database with information on the performance data of players across various elite leagues including youth leagues. A self-developed web crawler was used to collect data for the German U19 and U17 Bundesliga from their respective inception to the last season before the pandemic, when a different playing mode was introduced. The seasons included started with the 2003/2004 season for U19 and the 2007/2008 season for U17 and ended with the 2018/2019 season for both. In sum, the study included 672 teams with 19,373 players for the U19s and 504 teams with 14,110 players for the U17s.

The variables in this study were collected per team and per season. For each player in a team and a season, the number of nominations in the squad and the ToF for the respective season were recorded. All players who were nominated at least once in the team's squad were included in the further analyses of the distribution of the team's total playing minutes during the season. Including only players with at least one nomination ensures that only players who were actually considered for playing at least once during the season were included. Players who were injured and missing during the whole season or were not actually part of the team were therefore excluded from the analysis. It should be noted that being nominated does not necessarily lead to minutes of ToF, as players may remain on the bench for the entire season, e.g., backup goalkeepers who may not be used at all throughout the season.

Variables characterizing ToF distributions

A first strategy for characterizing ToF distributions is to look at appropriate suggestions for other domains in the literature. A widely used parameter describing the degree of evenness in the distribution of resources was introduced by the Italian sociologist and statistician Corrado Gini (1885–1965). His "Gini index" originally described inequalities in the distribution of incomes in national economies. Although this has remained the most famous application of the Gini index to date, it has also been used in many other domains to characterize the evenness of the distributions of a variable in a population, ranging from the distribution of galaxies in the universe to citations in certain research domains (Eliazar & Sokolov, 2012; Sitthiyot & Holasut, 2020).

Calculating the Gini index for a ToF distribution requires sorting the players in descending order according to the number of minutes played. The Lorenz curve is obtained by plotting the accumulated percentages of the players' ToF on the y axis with the accumulated percentages of the population on the x axis from the least to the most fielded player (no. 35 to no. 1 in our example in **Fig. 1**). The Gini area is the area between the Lorenz curve and the line of equality, and can be obtained by subtracting the area under the Lorenz curve from the area under the line of equality. The Gini index (47.3% in the example in **Fig. 1**) is then given by the quotient between the Gini area and the area under the line of equality. Thus, a totally even distribution results in a Lorenz curve on the line of equality, where the Gini area is 0% and the Gini index is 0%/50% = 0%. The other extreme is that a single player acquires all of the resources (not possible for ToF in football!). This results in a Lorenz curve of 0, a Gini area of 50%, and a Gini index of 50%/50% = 100%.

A second strategy to find indicators characterizing the ToF distributions is to make direct use of the properties of the distributions expressing meaningful domain-specific aspects. First, one could ask the question of how the available playing time (PT) of a team throughout a season is distributed across players. This may be expressed either by the number of most fielded players (NPL) accounting for 50% of total PT (50%PT) or the percentage of players (%PL) in the squad doing so. An illustration of these parameters is presented in **Fig. 1**. We refer to these variables as "number of players with 50% playing time" (NPL-50%PT) and "percentage of players with 50% playing time" (%PL-50%PT), respectively. In each case, a higher value indicates a more even distribution of ToF in a squad.

A second option is to examine the distribution from the perspective of the

players that receive ToF. This could be done by either determining the percentage of playing time (%PT) received by the 11 most fielded players (11PL) denoting the number of players in a starting lineup, or by determining the playing time received by 50% of the players (50%PL) in the squad (illustrations in Fig. 1). These variables are referred to as "percentage of playing time received by the 11 most fielded players" (%PT-11PL) and as "percentage of playing time received by the 50% most fielded players" in the squad (%PT-50%PL). For these two parameters, higher values indicate a more concentrated distribution of playing time in a squad.

These four domain-specific parameters for ToF distributions are, on the one hand, a systematic selection, but on the other hand one may expect redundancies between them. Therefore, the intercorrelations between these four parameters plus the Gini index were calculated. In addition, correlations between these four parameters and squad size were reported, as any influence of the number of available players on the distribution parameters is of interest.

There are few proposals in the literature for analyzing the distribution of the resource ToF among individual players. Thus, as mentioned earlier, a sub-goal of the study was to generate a recommendation for suitable domain-specific indicators. Therefore, we calculated and examined several variables from raw data as described in the following sections and exemplified in Fig. 1. For assessing the strengths and weaknesses of the indicators, we correlated the indicators of the whole sample ($n = 1176$ teams) with the squad size as well as with each other.

Sub-study 1: relationship between ToF distribution and competitive success

A key consideration in talent development strategy concerns the relevance of the acute competitive success of the team. This sub-study, therefore, examined at the correlation between the distribution of ToF and team success. The variable used to measure a team's competitive success (CompSucc) was the rank achieved in the final table in the respective season.

Sub-study 2: club strategies for ToF distribution

When either a high or a low concentration of playing time is the result of a stable club strategy, this should result in a consistent position of the club on the continuum between ST-CSS and LT-TDS described earlier. This should be the case seen over time, i.e., over many seasons, as well as for the U17 and U19 teams of the club. The latter aspect was investigated by correlating the ToF distribution indicators of the clubs' U17 and U19 teams. A high positive correlation indicates the existence of a club strategy of ToF distribution, for example, when the U17 team shows a very even (concentrated) distribution of ToF the U19 team is likely to show the same distribution characteristics. When U17 and U19 parameters are independent, ToF distributions may not be seen as the result of a stable club strategy. For the sake of comparability between the clubs, inclusion criteria specific to this sub-study had to be introduced, selecting clubs with many appearances of their youth teams in the Bundesliga. Clubs were included if their U17 and U19 team were permanently represented in the respective Bundesliga in the last six seasons observed (2013/2014 to 2018/2019). This resulted in 18 clubs being included. The mean values of the different ToF indicators and the squad sizes for the six seasons were correlated.

Data processing

The data processing started with calculating descriptive statistics. Standard statistical methods were used for the substudies. To analyze correlations between the various indicators for the ToF distribution and for the club strategies, the Bravais–Pearson correlation coefficient was calculated. The relationships between CompSucc (final ranking) and the distribution indicators were described with Spearman's rank correlation. A two-sided t test with a significance level of $\alpha = 0.05$ was carried out to test the sig-

Abstract

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Time-on-field distribution of soccer squads in the German U17 and U19 Bundesliga

Abstract

Background. A current reform in German youth soccer intends to promote individual talent development. The aim of our study was to investigate the distribution of time on the field (ToF) among a team's squad members as a marker for a club's strategies of talent development.

Methods. The study included 1176 teams comprising 33,483 players of the German U19 and U17 Bundesliga over a period of 16 years. We calculated a team's Gini index and self-designed variables to characterize the ToF distribution across the players of a squad.

Results. On average, squads consisted of 29.9 (±4.3) players, showing a partially increasing trend. The mean Gini index was 44.8% (±5.9), indicating a rather uneven distribution among the squad members. Overall, 50% of the team's available playing time was shared by 7.8 (±0.6) players (variable NPL-50%PT). The 11 most fielded players received 73.1% (±5.0) of the team's playing time (variable %PT-11PL). We found significant correlations between these indicators and the team's final rank in the season's table for both U17 and U19 (all $p < 0.001$). A significant correlation between a club's U17 and U19 teams for %PT-11PL suggests stable club strategies for the distribution of ToF.

Conclusion. The findings reflect club strategies of favoring short-term competitive success rather than long-term talent development under the previous competition structure. This underscores the necessity of the reform and highlights the importance of a thorough evaluation based on our benchmarks and methodological tools to prevent undesired side effects such as increasing squad sizes.

Keywords

Talent identification · Talent development · Gini index · Competitive success · Elite football

U19 (n=672) / U17 (n=504)	Squad Size	Gini Index	%PL-50%PT	%PT-50%PL	NPL-50%PT	%PT-11PL
Squad Size		0.617***	0.538***	-0.716***	0.384***	-0.414***
Gini Index	0.609***		0.973***	-0.950***	-0.250***	0.234***
%PL-50%PT	0.455***	0.836***		-0.877***	-0.212***	0.334***
%PT-50%PL	-0.549***	-0.702***	-0.876***		0.014	-0.036
NPL-50%PT	0.360***	-0.187***	-0.294***	0.124**		-0.922***
%PT-11PL	-0.393***	0.168***	0.263***	0.053	-0.911***	

Fig. 2 ▲ Pearson's correlations (*r*) of squad size and ToF indicators for the U17 teams (*below the diagonal*) and U19 teams (*above the diagonal*). Note: The cell *color* reflects the strength of the correlation: *white* = none, *green* = small, *yellow* = moderate, *orange* = large, *dark orange* = very large; %PL-50%PT: percentage of players with 50% playing time, %PT-50%PL: percentage of playing time received by the 50% most fielded players, NPL-50%PT: number of players with 50% playing time, %PT-11PL: percentage of playing time received by the 11 most fielded players; $^{**}p < 0.005$, $^{***}p < 0.001$

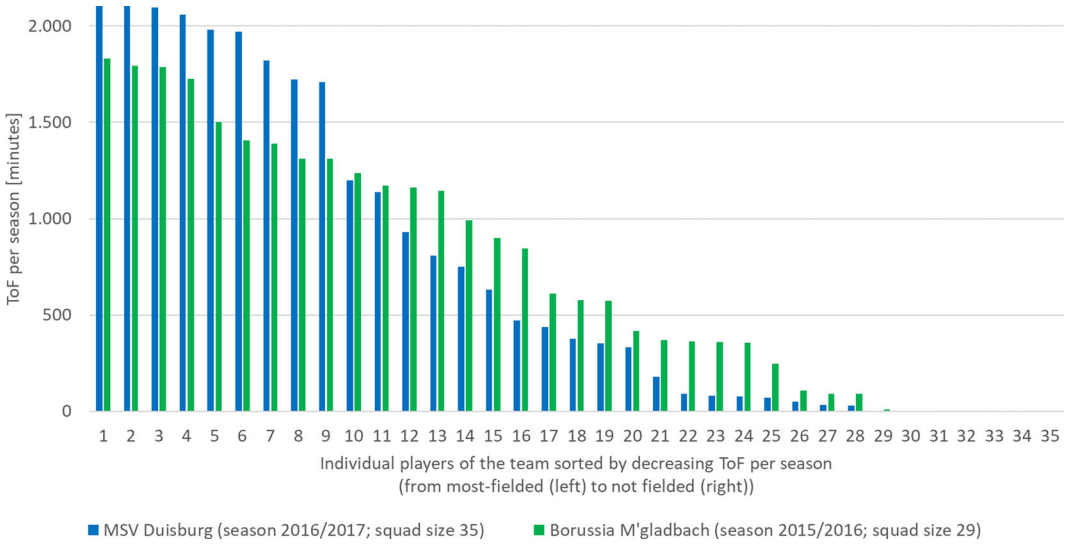

Fig. 3 ◀ Time on the field (*ToF*) of MSV Duisburg players during the 2016/2017 season (Gini index 58.4%) vs. Borussia Mönchengladbach players during the 2015/2016 season (Gini index 37.0%). Note that six players (nos. 30–35) of MSV Duisburg received no ToF at all, vs. 0 players of Borussia Mönchengladbach

nificance of the possible correlations. The strength of the correlation was interpreted as none ($|r| < 0.1$), small ($|r| < 0.3$), moderate ($|r| < 0.5$), large ($|r| < 0.7$), or very large ($|r| \geq 0.7$; Cohen, 1988). All statistical analyses were performed with JASP 0.14.1.

Results

ToF distribution indicators

Figure 2 shows the inter-correlations of the considered variables. Squad size showed moderate to very large correlations with the ToF distribution parameters. This is surprising in the case of the Gini index because it should theoretically be independent of population size (Sitthiyot & Holasut, 2020); however, we found a correlation with large effect size for both the U17 and the U19 teams. Regarding the self-developed indicators, the percentage-based indicators in particular showed a high dependency on squad size, which should be considered in further interpretations of these parameters. The number-based indicators seem to be comparably independent of squad size, however, as they showed only moderate correlations.

Another interesting feature of the inter-correlation matrix is the clustering of the ToF distribution variables in two sub-groups. There are very large correlations between the indicators Gini index, %PL-50%PT, and %PT-50%PL for both the U19 and the U17 teams (see **Fig. 2**). On the other hand, these indicators were not correlated, or only minimally correlated, with the indicators NPL-50%PT and %PT-11PL, while these two showed a very high correlation with each other. Thus, we have two sub-groups: (1) the highly squad-size-dependent percentage-based variables (%PL-50%PT and %PT-50%PL) and the Gini index, and (2) the indicators based on the number of players (NPL-50%PT and %PT-11PL) that were less dependent on squad size.

Consequently, in the remainder of the article, results are not reported for all developed ToF distribution indicators. As representative of the first group, we chose the well-established Gini index. For the second sub-group we report both indicators because both seem to be relevant for

Table 1 Descriptive data of ToF distribution parameters and squad size per season for all teams in sample

	U17 ($N = 504$; 12 seasons)				U19 ($N = 672$; 16 seasons)				Total	
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
Squad size	29.4	4.3	20	48	30.2	4.4	21	46	29.9	4.3
Gini index [%]	44.7	5.7	24.5	61.0	45.0	6.0	26.1	60.6	44.8	5.9
NPL-50%PT	7.7	0.5	6.6	9.5	7.8	0.6	6.4	10.6	7.8	0.6
%PT-11PL [%]	73.8	4.9	60.0	88.0	72.6	5.0	55.0	88.0	73.1	5.0

%PT-11PL percentage of playing time received by the 11 most fielded players, *NPL-50%PT* number of players with 50% playing time, *TOF* time on the field, *SD* standard deviation

practical purposes, for example, controlling (in the sense of economics) measures of a youth academy.

Descriptive data

Figure 3 shows two empirical distributions of ToF across the players of two squads: a U19 team with a high Gini index (MSV Duisburg, 58.4%) and a U19 team with a low one (Borussia Mönchengladbach, 37.0%). The figure shows that ToF in the MSV Duisburg U19 team is highly focused on only nine players, whereas it is more evenly distributed among the players of Borussia Mönchengladbach U19. Even in the latter case with a comparatively "even" ToF distribution, we find players in the squad with little to no playing time and others with up to 1800 min of ToF.

The descriptive data of the U17 and U19 teams per season are presented in **Table 1**. The number of players in the squads ranges from 20 to 48, with an average of 30. The average Gini index for the U17 and U19 is 45%, indicating a relatively large unequal distribution of the ToF across all squad players. On average, not even eight players share 50% of the valuable competition time (NPL-50%PT). The 11 fielded players who are most likely to be considered starters achieve more than 70% ToF.

Sub-study 1

To assess the relationship between ToF and competitive success (CompSucc) we calculated the correlation coefficients (Spearman's ρ) between the indicators and the team's final rank in the season's table. For NPL-50%PT (U17: $\rho = 0.220$; U19: $\rho = 0.189$) and %PT-11PL (U17: $\rho = -0.292$; U19: $\rho = -0.204$), there was a significant correlation with CompSucc for both U17 and U19 (all $p < 0.001$). Thus, the fewer players receiving 50% of ToF and the greater the ToF distributed across the 11 most fielded players (i.e., the higher the concentration of playing time), the more successful the team's season. The effect sizes were small, however. The season's success was barely dependent on the Gini index (U17: $\rho = -0.088$, $p < 0.05$; U19: $\rho = -0.075$, $p = 0.053$). For U19 teams, CompSucc was independent of squad size (U19: $\rho = 0.043$, $p = 0.265$), and for U17 teams, a large squad was weakly associated with less success ($\rho = 0.149$, $p < 0.001$).

Sub-study 2

Figure 4 shows the average %PT-11PL values for six seasons for the U17 and U19 teams of the 18 clubs included. Similar values for the two age levels are evident, either relatively low ones (Eintracht Frankfurt), indicating a relatively low concentration of ToF, or relatively high ones (Bayer Leverkusen), indicating a high concentration of playing time among the 11 most fielded players. Additionally, there are some clubs with large differences between U17 and U19 values, indicating that no overarching club strategy may be proved with the suggested method.

Between the U17 and U19 teams in the clubs of our sample, we found a significant correlation with moderate to strong effect size for the percentage of playing time acquired by the 11 most fielded players (%PT-11PL: $r = 0.471$, $p < 0.05$). This suggests a potentially stable club strategy for the distribution of ToF. Squad size, which may be considered highly influenced by the club management, showed only a slightly smaller but statistically insignificant effect ($r = 0.464$, $p = 0.053$). The correlation for the number of players receiving 50% of the playing time was small (NPL-50%PT: $r = 0.203$, $p = 0.419$), and the Gini index of the last 6 years showed only a spurious correlation ($r = 0.019$, $p = 0.941$).

Discussion

Talent development strategies

The basic assumption of this study is that different strategies of talent development in a club may be characterized by the distribution of ToF in their squads. The concept of a talent development strategy denotes an agreement in a club on the dominant aims of its talent department. This agreement may be explicit, for example, it may be formalized in a document consented on, or implicit, reflecting the dominant attitudes of the club decision-makers.

We assume a spectrum of talent development strategies that may be pursued, located between two extreme positions. The ST-CSS denotes priority on achieving momentary success in ongoing competitions, typically taking part in a youth league. The LT-TDS as an alternative approach focuses on the promotion of talents with the ultimate aim of preparing them for individual top performances at the age of top performance, which is typically at adult level only.

A coach nominating a team for the season matches who pursues ST-CSS would nominate the momentarily best performers in the squad, which, in turn, results in a distribution of ToF very much concentrated on these players. On the other hand, a coach pursuing LT-TDS would aim for an ideally even distribution of ToF among squad members, ensuring

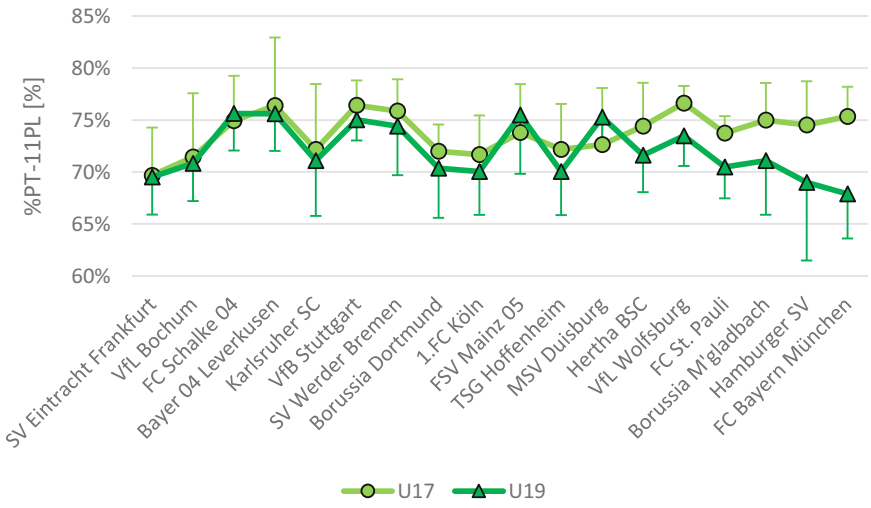

Fig. 4 ▲ Average percentage of ToF of the 11 most fielded players (%PT-11PL) for the U17 and U19 teams of the permanently represented clubs for the seasons 2013/2014–2018/2019. Note: *error bars* represent the standard deviations

they are all provided with experiences in tough competitions, since these are recognized as the most valuable stimuli in talent development.

Although these considerations demonstrate the content validity of ToF distribution as indicators of a specific talent development strategy, in a concrete setting several factors may prevent a clear expression of this relationship. These factors range from constraints inherent to the sport, e.g., when only a limited number of players are capable of playing in certain positions, playing time will be distributed among these few players. Constraints may also arise from organizational structures, for example, when the contracts of coaches contain rewards connected to success or when the short-term success-oriented attitudes of the professional department govern the youth department as well. Other factors potentially limiting the validity of ToF distribution as an indicator of a club's talent development strategy are discussed in the limitations section.

ToF distribution variables

In professional soccer, the playing time of each player (ToF) has been recorded for some time. However, to date, no indicators have been suggested in the literature to measure the distribution strategy of the resource playing time among squad players. We addressed this deficit in our study. The first of our indicators, the Gini index, correlated with squad size, although according to the literature it should be independent of population size (Sitthiyot & Holasut, 2020).

The other indicators were constructed using percentages of ToF distributions that we considered to be of practical interest: (1) What percentage of players in the squad received half of the available playing time (%PL-50%PT)? (2) What percentage of the available playing time was received by 50% of the most fielded players (%PT-50%PL)? These two indicators were also strongly dependent on squad size and largely correlated with the Gini index. Consequently, choosing one of these three indicators seems sufficient when referring to the squad-dependent distribution of a team's available playing time.

The two other indicators we introduced should be even more relevant in practice because they are expressed in absolute player numbers: (1) the absolute number of players who received 50% of the playing time (%PT-50%PL), and (2) the percentage of playing time that was received by the 11 most fielded players (%PT-11PL). We found that these indicators were less dependent on squad size than the three aforementioned indicators. The two absolute indicators correlated largely with each other but only moderately with the other three indicators. This suggests that one of these two indicators should also be used in further analyses.

Descriptive statistics

The descriptive statistics provide revealing results. First, we see rather large squad sizes of around 30 players on average. This implies that even when making use of all five substitutions allowed per match, only around half of the squad may appear on the pitch in a given match. The other half must wait for "natural" fluctuations due to injuries, changing tactical demands, or the dynamics of sporting form in the case of a strict competitive strategy (ST-CSS). Only when priority is given on developing all talents in the squad (LT-TDS) do all players have greater chances of being fielded, because in this case, a more even distribution of playing time is a strategic decision of the club.

Interpretations of the Gini index should not be made solely on the basis of its absolute value (between 0% and 100%), as the distribution of a resource is determined by domain-specific relationships. Instead, the coefficient is capable of revealing the relative inequalities in the distribution of ToF in football squads. The mean Gini index is around 44%, indicating that less than half of maximum equality is typically achieved. The relative position in the spectrum between the minimum of 24.5% and the maximum of 61.0% may be of greater interest than the absolute Gini index, for example, for youth academy managers who want to know how they distribute ToF in comparison with other clubs.

The results for the self-defined parameters of the ToF distributions may overall be interpreted as a generally largely uneven distribution of ToF among the squad players (see **Table 1**). It is interesting to consider the figures from the perspective of the players on the "wrong" side, i.e., the non-fielded players. When the 11 most fielded players account for almost 75% of playing time, this leaves only 25% for the other approximately 20 players in the squad. The same relation is expressed when fewer than eight players have 50% of playing time at their

disposal. This means that the remaining (approx.) 22 are competing for the other 50% of ToF.

As these figures speak clearly in favor of a strategy that distributes ToF very unequally across squads, they allow for inferences on the prevalence of the alternative youth academy strategies ST-CSS and LT-TDS. Our findings may clearly be interpreted as a widespread preference of ST-CSS over LT-TDS in the current youth academies. In addition, the relatively low dispersion in the ToF distributions means that this strategy is adopted rather uniformly by all the clubs involved, with only marginal and gradual deviations in the direction of LT-TDS in a few clubs. Taken together, the necessity of the reform mentioned initially is confirmed by the obvious dominance of ST-CSS, which does not represent long-term talent development.

Descriptive results show, on the one hand, a considerable homogeneity in the ToF distributions. There are some natural constraints on the degrees of freedom, such as the maximum number of players required per match (11 starting players + up to 5 substitutes), the natural turnover among available players due to injuries, fluctuations in player performance over a season, and within-season transfers. On the other hand, the absolute levels of the ToF distribution parameters create the impression that playing time is strongly concentrated on a limited number of players. The Gini index, for example, indicates that less than half of maximum equality is achieved on average. The other parameters also illustrate the substantial discrepancies between regularly fielded and non-fielded players, for example, when the 11 most fielded players account for almost 75% of playing time, the remaining (approx.) 20 players in the squad compete for the remaining 25% of playing time.

Sub-study 1

There is some evidence that a higher concentration of playing time on a few key players has a positive impact on competitive success. This finding is in line with the significant correlation between the strength of the RAE and final ranking in youth Bundesliga clubs (Augste & Lames, 2011), as a strong RAE is generally interpreted as preferring the momentarily physically strongest players. In both cases, it seems that ST-CSS not only has an impact on practical measures but is also rewarded by supporting the achievement of its primary goal, which is short-term success in competition. On the other hand, the relationship seems to be rather weak and thus deserves further and deeper investigation. Concentrating ToF on the key players may represent the successful ST-CSS, but perhaps not to the degree that club managers expect.

Sub-study 2

The clubs selected for this sub-study were those with a permanent appearance of their U17 and U19 teams in the respective Bundesliga in the last six seasons (n = 18). The study showed a significant correlation between the percentage of playing time received by the 11 most fielded players (%PT-11PL) for the U17s and U19s of the clubs. When there is a high share of playing time for these players (indicating ST-CSS) in U17, it is very likely that they also have a high share in U19 as well, and vice versa for a low share (LT-TDS). In this sense, one may refer to a club strategy for the distribution of ToF. It is interesting to note that the correlation for squad size was nearly significant, indicating that for squad size, too, there is a club strategy of having either larger or smaller squads. As there is even a moderate negative correlation between squad size and %PT-11PL (see **Fig. 2**), one may assume that squad size and concentration of ToF are two opposing aspects of the clubs' talent promotion strategy.

A specific result concerns the partially significant correlations of ToF parameters between U17 and U19 teams in the most successful clubs. As these findings are based on a large sample of seasons (six for each team), this may be interpreted as a similar (either more even or more concentrated) tendency of ToF distribution in a club between U17 and U19 teams. Furthermore, this suggests that a club-specific strategy exists for either distributing ToF in a concentrated or more even way. This finding implies that there is, in addition to the aforementioned constraints, some degree of freedom for the clubs to distribute playing time across their squads. In other words, there is some freedom to choose between ST-CSS and LT-TDS.

Limitations

The first limitation that must be mentioned concerns the validity of our ToF distribution parameters. We consider them indicators of an academy's strategy on how to distribute playing time across the squad members. Nevertheless, it must be acknowledged that the nomination or non-nomination of a player may be influenced by various factors other than the club's pursued strategy (ST-CSS or LT-TDS). These can be injuries, player transfers during winter break, or the actual course of a season, making ST-CSS mandatory during decisive phases or giving room for LT-TDS in others. Due to the large dataset with a sampling strategy that includes all available data for all relevant seasons (more than 30,000 players and more than 1000 teams), the descriptive value and the results of the sub-studies should, nevertheless, be highly informative.

Another limitation may be seen in the varying squad sizes. Squad size interferes strongly with some of our ToF variables, but may not necessarily in each case be seen as the result of a club's talent promotion strategy. Sometimes, players are listed for symbolic reasons or as an incentive, which may not reflect an actual intention to let them play. This may be particularly true for younger players, for example. Thus, the actual squad sizes vary in certain aspects somewhat arbitrarily, but exhibit a strong impact on the ToF distribution, as mentioned. This issue is somewhat mitigated by the results of sub-study 2, where the correlations showed that some clubs consistently prefer either relatively high or low squad sizes.

Summary and conclusion

A continuum of talent promotion strategies was assumed to have two poles:

short-term competitive success strategy (ST-CSS) focuses on momentary success and long-term talent development strategy (LT-TDS) on the long-term development of talents. Both strategies were expected to impact the distribution of playing time differently across the members of the club's squads. Therefore, this study aimed to analyze time-on-field (ToF) distributions across the squads of youth teams in the German Bundesliga. To this end, parameters were developed to characterize ToF distributions. Besides the Gini index used in literature to describe the distribution of a resource in a population, we developed four additional parameters.

A major result of our study is a recommendation on which parameters to use for the analysis of ToF distributions in future studies. We recommend using one indicator from the strongly squad-size-dependent group (Gini index, %PT-50%PL, %PL-50%PT) and one indicator from the moderately squad-size-dependent group (NPL-50%PT, %PT-11PL), because these two groups represent different aspects of ToF distributions. We recommend using the Gini index as representative of the first group, as this is known from other domains including economy and sociology. In the second group, the most meaningful indicator in our opinion is %PT-11PL because it shows the percentage of playing time received by the "starting 11,"—more precisely, the 11 most fielded players.

In the Introduction, the current reform of the format of youth competitions in the German Football Federation (DFB) was mentioned. One of its aims is to prioritize LT-TDS over ST-CSS because this serves the overall interest of German football. As concrete measures, for example, the number of possible substitutions per match was increased from 5 to 7 (6 + goalkeeper), and relegation was abolished (for academy teams). Our results show the need for this reform, as we observe, on average, high concentrations of playing time on a few key players, which naturally corresponds to spurious playing time for many less fielded players.

Nevertheless, there may be some undesired side effects with this reform:

- After the reform, a form of relegation still exists, although it is claimed to be avoided. As the clubs are divided into a higher and a lower league after a preliminary round, and only reaching the higher league allows a club to compete for the national championship, intense competition is likely to be expected to reach the upper group.
- Criticism from a traditional, more competition-centered attitude toward football might argue that reducing the rivalry for being in the starting line may have detrimental effects on developing resilience to selection pressure in young players. As they will face this pressure at the senior level, they will miss these essential experiences.
- Clubs may react to the increased number of substitutions by expanding their squad size. This, in turn, could negate many of the desired effects of this measure. This is not unlikely to happen, as evidenced by the increase in squad sizes in Youth Bundesliga history. For example, the average squad size of the U19s increased from 27 players in the 2003/2004 season to an average of 31 players in the 2010/2011 season (similar trend in U17s).

Taken together, the reform of the Youth Bundesliga format was necessary, as our study shows that uneven distributions of ToF were widespread, along with their detrimental effects on long-term talent development. Nevertheless, it is likely that undesired side effects challenge the success of this reform. For these reasons, it is mandatory to organize a formative evaluation of the reform, including tracking the development of ToF distributions in the following years. The tools and benchmarks for doing so are provided in this study.

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Declarations

Conflict of interest. C. Augste, M. Koller, B. Schröpf and M. Lames declare that they have no competing interests.

For this article no studies with human participants or animals were performed by any of the authors. All studies mentioned were in accordance with the ethical standards indicated in each case.

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