Impact of One Additional Substitution on Player Load and Coaching Tactics in Elite Football

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Featured Application: The findings justify further research and the implementation of an additional substitution in regular time to assess its impact on player load reduction.

Abstract: Professional football players, coaches, and researchers have discussed additional substitutions in football to reduce player load for a while. However, the effects of additional substitutions on the game have not yet been investigated in detail. The aim of this paper is to determine whether an additional substitution in (1) extra time and (2) regular time would be beneficial and would lead to (a) greater tactical influence of coaches on the match, (b) load reduction during one match, and (c) load reduction during one season. The methodological approach adopted includes two studies, both of which involve data analysis of substitution times (Study 1: \( n = 3060 \); Study 2: \( n = 1153 \)) as well as a survey of football coaches (Study 1: \( n = 37 \); Study 2: \( n = 25 \)). For assessing the effect of an additional substitution in regular time and in extra time, the substitutions made in the Bundesliga, U19-Bundesliga West, DFB-Cup, and 2018 World Cup were evaluated. The findings of this research clearly indicate the potential of an additional substitution by enabling almost 50% of additional load reduction in regular time and 27% in extra time. However, in practice, the findings showed the limits of an additional substitution in extra time on long-term load reduction.

Keywords: football rule change; player stress management; coaches survey; elite level soccer; youth player development; extra change

1. Introduction

The demand for additional substitutions in football has been raised by professional players, coaches, and recent scholarship [1,2]. This has been supplemented by research findings confirming reduced player performance in extra time [3,4]. Players of the top clubs and national teams have reported an ever-increasing strain due to both an increased speed of play during matches and an increased frequency of matches [5,6]. More competitions and less regeneration time have been identified as the prime sources of increasing injury frequency [7]. In order to counteract this increased burden, the International Football Association Board (IFAB) allowed an additional substitution during extra time of professional football matches in 2016 [8]. Information about the impact of this rule change on the game has largely remained limited [2,9]. Therefore, this study evaluates the effects of an additional substitution in regular time and extra time on the aspects of player load reduction and increase of tactical influence of coaches on the match.

The additional substitution in extra time analysed in this study was approved by the IFAB and the Fédération Internationale de Football Association (FIFA) in 2016 [10]. This rule change was specifically enacted by the IFAB to address the concerns of the global football community [8]. Recent scientific findings have indicated reduced player performance in extra time, which may have led to the requests making way for this rule change [3,4,11]. This aspect becomes particularly important in the light of the study by
Harper et al. [4], who found that there had been an increasing number of matches with extra time at recent World Cup finals. Since 1986, more than one-third (35%) of senior FIFA World Cup knockout matches have required 120 min of match-play [4]. Therefore, substituting a player with better physical performance than a starting player has a positive impact on the game [12,13]. Higher load causes not only a decrease in performance but also increases the potential for injuries. Despite this, the physical stress on athletes at the national level has increased over the recent years. This is caused by the higher speed of the game as well as the greater number of matches played per season [6]. The combination of higher load and less regeneration time has caused an increased frequency of injury for players [7]. The majority of coaches in football consider substitutes important for success during a football match, despite the limited influence that coaches have in reducing player load and changing their starting line-up or substitutions [14].

Substitutions can have a significant impact on a game of football, and the tactical influence of coaches on the match has been demonstrated in several studies [9,15,16]. For example, Trainor [13] concluded that both the substitutes and the substituted players scored more goals than players who were used for the entire duration of the game. Previous research has also indicated the physical advantages of using substitutes; namely, they cover greater distances with high-intensity [17,18] and medium-intensity runs [19] than the players who have been in the game from the start [20]. This is in line with the practical perception by the coaches who state the main justification for substitutions being the perceived ability of these players to have a physical and tactical impact [15]. Overall, substitution behaviour is dependent during the course of the match on factors such as score and injuries [9,14,21]. There are several studies that suggest the best possible timing of substitutions using various approaches such as modelling the effect probabilities on match outcomes; none of them focus on improving the understanding of how the timing of substitutions influences the management of player load [22,23].

In order to assess the impact of substitutions, it is relevant to study physiological conditions such as variations in exercise intensity and fatigue among football players. With regard to exercise intensity, several studies on match analysis have outlined that the volume of high-intensity exercises decreases towards the end of matches in professional and semi-professional football [19,21]. This has been demonstrated across the board in all age, gender, or performance categories [24,25]. Therein, the quantity of sprinting, high-intensity running, and distance covered was lower in the second half of a match than in the first half [19,26]. In addition, high-intensity running was significantly reduced in the last 15 min of an elite football match [19]. Research has indicated that player load progressively increases during a match with peak loads based on multiple factors [27]. Therefore, the physical conditions of the game make use of substitutions effective in reducing the load on the players.

Frequent substitutions can reduce fatigue during a match and between matches and help maintain the health of athletes through squad rotation [28,29]. This becomes even more consequential when the player load is compared to the player rest time. On average, players face 254 h and 196 days of load exposure in up to 60 matches and 220 training sessions per season, which corresponds to a ratio of two days of load to one day of recovery [30,31]. National team players who also compete in international club-level matches have even more playing hours and, therefore, less recovery time, which may further increase the importance of load reductions for these elite players through substitutions [30–32].

Existing research on the effects of an additional substitution is based on the observation of the coaches’ substitution behaviour in the German Bundesliga and Italian Serie A, when three substitutions, instead of two, were implemented in the national leagues for the 1995/96 season [1,9]. Both the studies indicated that with an additional substitution opportunity, substitutions were used significantly more often and earlier in the match [1,9]. Varela-Quintana et al. [1] and Geyer [9] both found similar average substitution times overall in matches with three and two substitutions allowed. Furthermore, the additional
substitution resulted in the first two substitutions being made about 5 min earlier [1], and the use of the second substitution was increased by about 20% [9].

However, whether an additional substitution is an effective tool to reduce the player load in a match or over the course of a season or not remains unexplored.

**Study 1**

Evaluation of TOS: An objective data evaluation of the time of substitution (TOS), i.e., the minute of the substitution, was carried out to prove whether an additional substitution in regular or extra time would theoretically be beneficial for the reduction of player load for the team as well as the tactical influence of the coaches on the match. Calculations were made to assess the potential benefit over the period of one match and one season.

Coaches survey: A qualitative coaches survey was conducted in order to examine whether an additional substitution in regular or extra time would be practically beneficial to the reduction of player load or not. Furthermore, the tactical influence of coaches on the match was subsequently determined. Responses were analysed to assess coaches’ evaluation of the practical impact of additional substitution in terms of potential benefits over the period of one match and one season.

2. Materials and Methods

2.1. Subjects and Design

2.1.1. Evaluation of TOS

Due to a limit of maximum three substitutions allowed in regular time, comparability within the same playing level was limited. To achieve comparability, data from the highest German national youth league allowing four substitutions was included. Therefore, the TOS data of 306 German Bundesliga matches ($n = 1751, M_{TOS} = 71.25, SD = 14.85$) were compared to the TOS of 182 German U19-Bundesliga West matches ($n = 1309, M_{TOS} = 67.03, SD = 15.94$). Both collected datasets were post hoc from the 2015/16 season and obtained from the official match data [33,34]. In line with Walker and Hawkins [31], both competitions are based around a program, where there are 6–7 days between competitive matches.

Based on the findings of Bangsbo et al. [32] on the progressive increase in fatigue, as well as the findings by Yue et al. [35] on the linear increase of mean specific kinetic energy, the following load reduction calculations assumed a simplified linear increase in player load during a match. Therefore, the theoretical basis underlying the data evaluation started with 0% load at kick-off and linearly increased to 100% load at the end of the match (Figure A1). For the evaluation of the impact of an additional substitution on load reduction and the tactical influence of the coaches on the game, the actual share of the additional substitution in the substitution contingent (one out of four; 25%) was taken as a basis. Therefore, a relative increase of the substitution contingent higher than 25% would be considered beneficial as the additional substitution for tactical influence of coaches on the match. Furthermore, an increase of load reduction higher than the relative increase of the substitution contingent would characterise the additional substitution as beneficial for load reduction, because the gained advantage of the load reduction was greater than the cost of the additional substitution.

2.1.2. Coaches Survey

In total, 37 coaches (experience: $M = 10.21$ years, $SD = 7.21$ years, with a minimum requirement of UEFA B-level coaching licence—15 youth football coaches and 22 adult football coaches) participated in this study. The youth football coaches worked with the age groups of U-16 up to U-19 at professional youth football academies in Germany. The adult football coaches worked at a playing level ranging from regional to national level.

The coaches survey was conducted using the online SurveyMonkey tool (SurveyMonkey, San Mateo, CA, USA; http://www.surveymonkey.com (accessed on 24 August 2020)). The questionnaire included two open questions and nine closed questions with
options for scaled appraisal. For the assessment of the benefit of one extra substitution, the coaches were given six possible response options for each question; this way, the choice of the middle category was prevented, and a tendency had to be demonstrated by the respondents [36]. The survey was validated through a qualitative review of three responses provided by coaches with a UEFA B-level coaching licence and a master’s degree in sports science. As no concerns or misunderstandings occurred, we proceeded with the survey as planned.

The first two questions concerned the coaches’ anamnesis, (1) asking about coaching licence level and coaching experience as well as (2) the age group (youth/adult) and playing level of their currently coached team. The third question targeted the (3) coaches’ opinion on the current amount of three substitutions in adult football. Here, a middle response option was deliberately provided, because the indication of no tendency was considered a valuable response in this case. Questions four and five were used to ask about the aspects of (4.1) tactical influence of coaches on the match, (4.2) load reduction in one match, and (4.3) load reduction in one season, as well as an (5) overall rating on the possibility of a fourth substitution in regular time. Questions six and seven were about the aspects of (6.1) tactical influence of coaches on the match, (6.2) load reduction in one match, and (6.3) load reduction in one season, as well as (7) an overall rating on the possibility of a fourth substitution in extra time. The other questions concerned, besides the in-theory benefits, the practical implications of the one extra substitution rule. The respondents’ assessment of the influence of the rule change (8) regarding the cut-off time and time management, as well as (9) the potential positive benefits in comparison to potential negative effects were evaluated. (10) The reasons for the substitution behaviour of the coaches provided information about the causality with the timing of the substitutions. The last question evaluated a possible (11) increase of playing time for youth/young players if an additional substitution was sent on the field.

2.2. Methodology
Evaluation of TOS

In this section, we present the relevant parameters and calculations for the evaluation of this change.

The cumulative load (CL) of a team per match corresponds to the product of the match duration and the number of players on the pitch. In line with previous research, goalkeeper substitutions were excluded, and therefore, the number of players observed for the calculation was reduced to 10 [1,9]. Additionally, the average stoppage time of 3.4 min in the Bundesliga was added to the match time for a more realistic evaluation. In summary, a consolidated CL in football of 934 min was calculated with an average of 93.4 min of match time and 10 players.

The maximum number of substitutions (max_NS) in one season accounted for a total of 1836 possible substitutions in the German Bundesliga (34 match days × 9 matches per match day × 6 substitutions per match) and 1456 possible substitutions in the German U-19-Bundesliga West (26 match days × 7 matches per match day × 8 substitutions per match). Moreover, the average number of substitutions per match and the utilisation rate (average percentage of substitutions used per match) were used in the calculations. Load reduction per substitution in minutes Equation (1) and the relative load reduction per substitution in percent Equation (2) were calculated as follows:

\[
(MD - OTOS) = LRpS. \tag{1}
\]

Remark 1. MD: match duration; OTOS: average time of substitution; LRpS: load reduction per substitution.
LRpS \; \frac{CL}{CL} = rLRpS. \hspace{1cm} (2)

**Remark 2.** LRpS: load reduction per substitution; CL: cumulated load; rLRpS: relative load reduction per substitution.

The relative load reductions of the Bundesliga and U-19 Bundesliga West were calculated with the following formula:

\[
\frac{(MD - OTOS) \times ONS}{CL} = rLR. \hspace{1cm} (3)
\]

**Remark 3.** MD: match duration; OTOS: average time of substitution; ONS: average number of substitutions; CL: cumulated load; rLR: relative load reduction.

The 90th minute was added as the time of the fourth substitution to the average TOS with three substitutions in regular time, because this related to the earliest possible TOS with a fourth substitution in extra time, therefore leading to the greatest possible load reduction. To calculate the maximum benefit of an additional substitution in extra time on load reduction, the following equation was used:

\[
\left(\frac{3}{4} \times OTOSr\right) + \left(\frac{1}{4} \times 90\right) = \text{min}_\text{OTOS4x}. \hspace{1cm} (4)
\]

In extra time, the CL fundamentally added up to 1234 min (123.4 min \times 10 players). The relative maximum load reduction with an additional substitution in extra time (max_rLRx) was calculated as follows:

\[
\frac{(MD - \text{min}_\text{OTOS4x}) \times NS}{CL} = \text{max}_\text{rLRx}. \hspace{1cm} (5)
\]

**Remark 4.** min_\text{OTOS4x}: earliest possible average time of substitutions with added substitution in extra time; MD: match duration; NS: number of substitutions; CL: cumulated load; max_rLRx: maximum relative load reduction with added substitution in extra time.

The relative maximum load reduction per season with an additional substitution in extra time was calculated for a team playing in the German Bundesliga (34 matches), in the national DFB-Cup (6 matches), and in an International European Cup (13 matches) as follows:

\[
\frac{\text{max}_\text{LRx} \times NGx}{NGr \times CLr + NGx \times CLx} = \text{max}_\text{LRx per season}. \hspace{1cm} (6)
\]

**Remark 5.** max_LRx: maximum load reduction with additional substitution in extra time; NGx: number of matches ending in extra time; NGr: number of matches ending in regular time; CLr: cumulated load of matches ending in regular time; CLx: cumulated load of matches ending in extra time; max_LRx per season: maximum relative load reduction per season with added substitution in extra time.

Additionally, the load reduction with four substitutions was compared to the load reduction with three substitutions to assess the benefit that could be gained with an additional substitution. This increase of load reduction (ILR) as calculated as follows:

\[
\frac{LR4S - LR3S}{LR3S} = ILR. \hspace{1cm} (7)
\]
Remark 6. LR4S: load reduction with four substitutions; LR3S: load reduction with three substitutions; ILR: increase of load reduction.

The relative increase of the substitution contingent (rISC) was calculated as follows:

\[
\frac{\text{ONS}4r - \text{ONS}3r}{\text{ONS}3r} = \text{rISC}. \quad (8)
\]

Remark 7. ØNS4r: average number of substitutions with four substitutions in regular time; ØNS3r: average number of substitutions with three substitutions in regular time; rISC: relative increase of substitution contingent.

2.3. Statistical Analysis

2.3.1. Evaluation of TOS

The TOS were not distributed evenly within the groups (p < 0.05). Therefore, a Mann–Whitney U-Test was used to evaluate potential differences in TOS between a substitution contingent of three and four. To assess the impact of an additional substitution in regular time and extra time on the tactical influence of coaches on the match, the rISC was compared to the threshold of the proportion of one substitution in the contingent of four (25%). The effects were evaluated as beneficial (rISC > 25%), non-beneficial (25% ≥ rISC ≥ 0%), or counter-beneficial (0% > rISC).

Moreover, to assess the effect of an additional substitution in regular time on load reduction, the ILR was compared to the threshold of the rISC. The effect was evaluated as beneficial (ILR > rISC), non-beneficial (rISC ≥ ILR ≥ 0%), or counter-beneficial (0% > ILR).

Lastly, to assess the impact of an additional substitution in extra time on load reduction, the maximum relative load reduction with added substitution in extra time (max_rLRx) per match and per season was compared to the threshold of the rISC. The effect was evaluated as beneficial (max_rLRx > rISC), non-beneficial (rISC ≥ max_rLRx ≥ 0%), or counter-beneficial (0% > max_rLRx). Effect sizes were calculated in \( \eta^2 \) and interpreted in accordance with Cohen [37]. Subsequently, a small effect is found at \( \eta^2 = 0.01 \), a medium effect is found at \( \eta^2 = 0.06 \), and a large effect is found at \( \eta^2 = 0.14 \).

2.3.2. Coaches Survey

In the data evaluation, the mean values (M) of the responses were compared to the respective medians (m) of the given response options with a one-sample t-test. The tested aspect was considered as beneficial (M > m), non-beneficial (M = m), and counter-beneficial (M < m). Effect sizes were calculated in \( d \) and interpreted in accordance with Cohen [37]. Subsequently, a small effect starts at \( d = 0.2 \), a medium effect at \( d = 0.5 \), and a large effect at \( d = 0.8 \).

3. Results

3.1. Evaluation of TOS

For an overview, all the results are presented in Table 1. Our analysis showed that the overall average TOS of the matches with three substitutions (M_{TOS} = 71.25, SD = 14.85) was significantly higher than in matches with four substitutions (M_{TOS} = 67.03, SD = 15.94), \( U = 1,326,910.00, Z = -7.486, p < 0.001, \eta^2 = 0.018 \). The average TOS of the first three substitutions in matches with a substitution contingent of three (M_{TOS} = 71.25, SD = 14.85) was significantly higher than in matches with a substitution contingent of four (M_{TOS} = 63.66, SD = 15.57), \( U = 652,170.00, Z = -13.037, p < 0.001, \eta^2 = 0.061 \).
Overview of the relevant data results from Study 1; comparison of the Bundesliga and U-19 Bundesliga West.

| Variables               | Bundesliga | U-19 Bundesliga West | Statistics |
|-------------------------|------------|----------------------|------------|
| allowed substitutions   | 3          | 4                    |            |
| øTOS [min of play]      | 71.25 (SD = 14.85) | 67.03 (SD = 15.94) | p < 0.001, $\eta^2 = 0.018$ |
| øTOS1 [min of play]     | 56.45 (SD = 14.31) | 51.78 (SD = 14.61) | p < 0.001, $\eta^2 = 0.064$ |
| øTOS2 [min of play]     | 72.96 (SD = 10.73) | 65.86 (SD = 11.73) | p < 0.001, $\eta^2 = 0.089$ |
| øTOS3 [min of play]     | 83.02 (SD = 7.08)  | 74.19 (SD = 10.93) | p < 0.001, $\eta^2 = 0.173$ |
| øTOS4 [min of play]     | -          | 80.95 (SD = 7.89)   |            |
| ØNS                     | 2.86       | 3.60                 | rISC = 25.87% |
| LRP [min]               | 22.15      | 26.37                |            |
| rLRpS                   | 2.37%      | 2.82%                |            |
| rLR                     | 6.79%      | 10.15%               | ILR = 49.63% |

Note. TOS: times of substitutions; ØNS: average number of substitutions; LRpS: load reduction per substitution; rLRpS: relative load reduction per substitution; rLR: relative load reduction; rISC: relative increase of the substitution contingent; ILR: increase of load reduction.

Additionally, each substitution was made significantly earlier in matches with four substitutions with an increasing effect size. The first substitution in matches with a substitution contingent of four ($M_{TOS1} = 51.78$, $SD = 14.61$) was significantly earlier than in matches with three substitutions ($M_{TOS1} = 56.45$, $SD = 14.31$) with a small effect size, $U = 77,220.50$, $Z = −7.866$, $p < 0.001$, $\eta^2 = 0.064$. The second substitution in matches with a substitution contingent of four ($M_{TOS2} = 65.86$, $SD = 11.73$) was significantly earlier than in matches with three substitutions ($M_{TOS2} = 72.96$, $SD = 10.73$) with a small effect size, $U = 70,440.00$, $Z = −9.152$, $p < 0.001$, $\eta^2 = 0.089$. The third substitution in matches with a substitution contingent of four ($M_{TOS3} = 74.19$, $SD = 10.93$) was significantly earlier than in matches with three substitutions ($M_{TOS3} = 83.02$, $SD = 7.08$) with a moderate effect size, $U = 45,162.00$, $Z = −12.270$, $p < 0.001$, $\eta^2 = 0.173$.

The overall utilisation rate of the matches with three substitutions ($M_{UR} = 95.37\%$, $SD = 21.02\%$) was significantly higher than in matches with four substitutions ($M_{UR} = 89.90\%$, $SD = 30.14\%$), $U = 1,263,542.00$, $Z = −6.085$, $p < 0.001$, $\eta^2 = 0.011$. The utilisation rate of the first three substitutions did not differ between matches with a substitution contingent of three ($M_{UR} = 95.37\%$, $SD = 21.02\%$) and matches with a substitution contingent of four ($M_{UR} = 96.52\%$, $SD = 18.34\%$), $U = 990,930.00$, $Z = −1.500$, $p = 0.134$, $\eta^2 = 0.002$. The resulting average number of substitutions was 2.86 in Bundesliga and 3.60 in U-19 Bundesliga matches. The $rISC$ was calculated at 25.87\% in Equation (8) and is higher than the actual share of the added substitution in the substitution contingent (25\%). Therefore, the additional substitution in regular time was assessed as beneficial towards the tactical influence of coaches on the match.

The results of the utilisation rate per substitution showed no differences between matches with a substitution contingent of three and four. Nearly all (99.84\%, 611/612) of the first substitutions, 98.37\% (602/612) of the second substitutions, and 87.91\% (538/612) of the third substitutions were used in matches with substitution contingent of three. Nearly all (99.18\%, 361/364) of the first and the second substitutions, 91.71\% (332/364) of the third substitutions, and 70.05\% (255/364) of the fourth substitutions were used in matches with a substitution contingent of four.

The relative load reduction per substitution was calculated at 2.37\% in Equation (2), resulting in the relative load reduction of 6.79\% in Equation (3) for every match with three substitutions. For matches with a substitution contingent of four, the relative load reduction per substitution was 2.82\%, resulting in the relative load reduction of 10.15\% per match. In comparison, the calculated increase in load reduction in Equation (7) indicated an increase of 49.63\% with the additional substitution in regular time, which is higher than the calculated relative increase of the substitution contingent of 25.87\%. Therefore, the additional substitution in regular time was assessed as beneficial towards load reduction.

An additional substitution in extra time showed a maximum possible load reduction of 15.38\% in Equation (5), with the earliest possible average time of substitutions with
added substitution in extra time being 75.94 min in Equation (4). This represents a 27.28% increase in load reduction compared to a substitution contingent of three players in extra time. Therefore, the additional substitution in extra time was assessed as beneficial towards load reduction in one match.

On the contrary, the maximum possible load reduction per season with additional substitution in extra time was calculated at 3.69% in Equation (6), resembling an increase of 22.83% compared to the load reduction per season with a substitution contingent of three. The increase of the calculated maximum possible load reduction per season with additional substitution in extra time (22.83%) was lower than the calculated relative increase of the substitution contingent of 25.87%. Therefore, the additional substitution in extra time was assessed as non-beneficial towards load reduction in a season.

3.2. Coaches Survey

The results of the questionnaire showed that coaches considered the current contingent of three substitutions in adult football too few \((MQ_3 = 2.270, SD = 0.838)\) with a large effect size, \(t(36) = −5.295, p < 0.001, d = −1.765\).

Moreover, the coaches assessed an additional substitution in regular time as beneficial with regard to tactical influence of coaches on the match \((MQ_{4.1} = 4.297, SD = 1.664)\), \(t(36) = 2.914, p = 0.006, d = 0.971\), load reduction during a match \((MQ_{4.2} = 4.216, SD = 1.475)\), \(t(36) = 2.955, p = 0.005, d = 0.985\), load reduction during a season \((MQ_{4.3} = 4.00, SD = 1.580)\), \(t(36) = 2.235, p = 0.032, d = 0.745\), and overall \((MQ_5 = 3.757, SD = 1.480)\), \(t(36) = 2.221, p = 0.033, d = 0.740\) (Figure 1).

**Figure 1.** Coaches survey: Mean of answers to questions four and five on additional substitution in regular time. Note: * signals a significantly \((p \leq 0.05)\) higher mean value than the median (3.5) and thus the assessment of the additional substitution with regard to the queried aspect as beneficial by the coaches.

Coaches determined the additional substitution in extra time as beneficial regarding the aspects of tactical influence of coaches on the match \((MQ_{6.1} = 4.595, SD = 1.572)\), \(t(36) = 4.237, p < 0.001, d = 1.412\), load reduction in one match \((MQ_{6.2} = 4.757, SD = 1.321)\), \(t(36) = 5.787, p < 0.001, d = 1.929\) and overall \((MQ_7 = 3.973, SD = 1.364)\), \(t(36) = 2.109, p = 0.042, d = 0.703\). In contrast, regarding load reduction in one season \((MQ_{6.3} = 3.432, SD = 1.686)\), the additional substitution in extra time was judged as non-beneficial by the coaches, \(t(36) = −0.241, p = 0.811, d = −0.080\) (Figure 2).
The coaches indicated that an additional substitution would not lead to an increase in stalling the match ($M_{Q8} = 3.351$, $SD = 1.637$), $t(36) = -0.552$, $p = 0.584$, $d = -0.184$. The coaches’ responses also showed that the potential positive effects of an additional substitution would exceed the potential time consumption ($M_{Q9} = 4.378$, $SD = 1.341$), $t(36) = 3.985$, $p < 0.001$, $d = 1.328$. In response to the question about the reasons for late substitutions, coaches indicated that caution against injuries ($M_{Q10.1} = 3.216$, $SD = 1.456$), $t(36) = -1.186$, $p = 0.243$, $d = -0.395$, and time management ($M_{Q10.3} = 3.459$, $SD = 1.406$) were less decisive factors, $t(36) = -0.175$, $p = 0.862$, $d = 0.058$. In turn, the results showed that game strategy ($M_{Q10.2} = 4.162$, $SD = 1.302$) was an important factor for substituting late, $t(36) = 3.094$, $p = 0.004$, $d = 1.031$. The coaches’ responses indicated an increase of playing time for youth/young players if an additional substitution was admitted ($M_{Q11} = 4.514$, $SD = 1.283$), $t(36) = 4.806$, $p < 0.001$, $d = 1.602$.

4. Discussion

The results of the dual methodology using data analysis and subjective questionnaire indicates that an additional substitution in extra time could be beneficial for the tactical influence of coaches on the match. While the corresponding survey responses show a clear tendency towards a perceived benefit of an additional substitution, the data indicate a theoretical increase of 33% and practical increase of 26% of the substitution contingent and, therefore, of tactical influence of coaches on the match. Moreover, the findings of this study indicate that an additional substitution in regular time is beneficial for tactical influence of coaches on the match. Both questionnaire responses and the increase of tactical influence of coaches on the match by 26% more substitutions support this finding.

Regarding the effect on player load, the results indicate that an additional substitution in regular time is beneficial for load reduction in one match. The data evaluation shows a 4% reduction of the match load with a fourth substitution in regular time. This resembles an ILR by almost 50% compared to the load reduction of three substitutions (Figure 3).
The corresponding survey responses by the coaches reinforce this finding. In conclusion, the results of the dual methodology indicate that an additional substitution in regular time is potentially beneficial for load reduction in one season. Furthermore, the current results indicate that an additional substitution in extra time could be beneficial for load reduction in one match. This can be supported both by the responses of coaches and the maximum possible load reduction with additional substitution in extra time of 27%. On the contrary, an additional substitution in extra time was found to be non-beneficial for load reduction in a season. The survey responses as well as the data evaluation reiterated this result. While an additional substitution might have an effect on load reduction for one particular match, only a few matches during a season actually go into extra time. Thus, even a Bundesliga team participating in an International European Cup would have a maximum increase in load reduction of 23% over the course of a whole season. This effect might be worth investigating for national teams competing at Continental- or World Cups, where a higher percentage of matches with extra time are played. The maximum percentage of matches with extra times is 20% for the Bundesliga club, while 35% of World Cup finals go into extra time [3].

Study 2

Evaluation of TOS: In order to evaluate whether an additional substitution in extra time was practically beneficial concerning the reduction of player load or not as well as tactical influence of coaches on the match, an objective data evaluation of substitution times was conducted. Calculations were made to assess the actual benefit over the period of one match and a tournament.

Coaches survey: In order to evaluate if an additional substitution in extra time was practically beneficial concerning the reduction of player load as well as tactical influence of coaches on the match, a qualitative coaches survey was documented. Responses were analysed to assess the coaches’ evaluation of the practical impact of additional substitution in terms of the actual benefits over the period of a match and a tournament.

5. Materials and Methods
5.1. Subjects and Design
5.1.1. Evaluation of TOS

Due to the new rules of football allowing an additional substitution in extra time, an evaluation of the TOS in a national cup event at the club level and at the World Cup for national teams was conducted. The TOS of 126 German DFB-Cup matches (n = 778,
MTOS = 72.80, SD = 9.42) of the 2017/18 and 2018/19 season as well as the 64 matches from the 2018 World Cup (n = 385, MTOS = 72.17, SD = 9.30) were analysed.

In line with Study 1, calculations were based on a simplified linear increase in player load during a match (Figure A1) [32].

Again, for the evaluation of the impact of an additional substitution on load reduction and the tactical influence of the coaches on the game, the actual share of the additional substitution in the substitution contingent (one out of four; 25%) was taken as a basis. A relative increase of the substitution contingent higher than 25% would evaluate the additional substitution as beneficial for tactical influence of coaches on the match. Furthermore, a higher increase of the load reduction than the relative increase of the substitution contingent would characterise the additional substitution as beneficial for load reduction.

5.1.2. Coaches Survey

Twenty-five coaches (experience: M = 9.50 years, SD = 7.90 years, 4 youth football coaches and 21 adult football coaches) participated in this study. The coaches were officially licenced by the UEFA (C-level = 4, B-level = 10, Elite-Youth-level = 3, A-level = 8). The youth football coaches worked with the age groups of U-15 up to U-19 at professional youth football academies in Germany. The adult football coaches worked at a playing level ranging from regional to national level in Germany.

The questionnaire included two open questions and four closed questions with options for scaled appraisal. Congruent with Study 1, the coaches were given six possible response options for each question.

The first two questions concerned the coaches’ anamnesis, asking about (1) coaching licence level, coaching experience, as well as the (2) age group (youth/adult) and playing level of the team coached at the time. The third question targeted the (3) coaches’ opinion on the current amount of three substitutions in adult football. Here, a middle response option was deliberately provided, because the indication of no tendency was considered a valuable response in this case [36]. The coaches were asked for their opinion on whether the additional substitution in extra time would lead to a (4.1) more frequent use and a (4.2) earlier use of the third substitution in regular time or not. Question five was concerned with the aspects of (5.1) load reduction in one match and (5.2) load reduction in one season of the fourth substitution in extra time (cf. Study 1: question 6.2 and 6.3). In contrast with Study 1, the coaches now actually had practical experience with the additional substitutions over two seasons, which may result in a different assessment. Lastly, the coaches gave their opinion on (6) the best size of the substitution contingent. They were given the options from one to six substitutions.

5.2. Methodology

Evaluation of TOS

All calculations regarding the tactical influence of coaches on the match and load reduction were based on the same equations used in Study 1. Instead of using the 90th minute as the earliest possible time of substitution for a fourth substitution in extra time, the actual average TOS of the fourth substitution in extra time was used to calculate for load reduction in one match and a tournament, as shown in Equations (5) and (6).

5.3. Statistical Analysis

5.3.1. Evaluation of TOS

Evaluation of TOS: The TOS data were not evenly distributed within the groups (p < 0.05). Therefore, a Mann–Whitney U-Test was used to evaluate potential differences in TOS of the first three substitutions between matches with and without extra time. To assess the impact of an additional substitution in extra time on the tactical influence of coaches on the match, the rISC was compared to the threshold of the proportion of one substitution in the contingent of four (25%). The effects were evaluated as beneficial (rISC > 25%), non-beneficial (25% ≥ rISC ≥ 0%), or counter-beneficial (0% > rISC).
Furthermore, to assess the impact of an additional substitution in extra time on load reduction, the relative load reduction with additional substitution in extra time (rLRx) per match and per tournament was compared to the threshold of the rISC. The effect was evaluated as beneficial (rLRx > rISC), non-beneficial (rISC ≥ rLRx ≥ 0%), or counter-beneficial (0% > rLRx). Effect sizes were calculated in $\eta^2$ and interpreted in accordance with Cohen [37]. Subsequently, a small effect is found at $\eta^2 = 0.01$, a medium effect is found at $\eta^2 = 0.06$, and a large effect is found at $\eta^2 = 0.14$.

5.3.2. Coaches Survey

In the data evaluation, the mean values (M) of the responses were compared to the respective medians (m) of the given response options with a one-sample $t$-test. The tested aspect was considered as beneficial (M > m), non-beneficial (M = m), and counter-beneficial (M < m). Effect sizes were calculated in $d$ and interpreted in accordance with Cohen [37]. Subsequently, a small effect starts at $d = 0.2$, a medium effect starts at $d = 0.5$, and a large effect starts at $d = 0.8$.

6. Results

6.1. Evaluation of TOS

All results are presented in Table 2 following this results section. The analysis showed that the overall average TOS of the matches without extra time ($M_{TOS} = 69.75, SD = 14.96$) was significantly lower than in matches with extra time ($M_{TOS} = 84.42, SD = 19.84$), $U = 59,138.50, Z = −9.537, p < 0.001, \eta^2 = 0.018$. The average TOS of the first three substitutions in matches without extra time ($M_{TOS1} = 57.93, SD = 14.62$) was significantly lower than in matches with extra time ($M_{TOS} = 69.75, SD = 14.96$) was significantly lower than in matches with extra time ($M_{TOS} = 69.75, SD = 14.96$). The average TOS of the first substitution in matches without extra time ($M_{TOS1} = 57.93, SD = 14.62$) was significantly lower than in matches with extra time ($M_{TOS} = 69.75, SD = 14.96$). The average TOS of the second substitution in matches without extra time ($M_{TOS2} = 71.25, SD = 10.17$) was significantly lower than in matches with extra time ($M_{TOS} = 77.60, SD = 17.32$), $U = 59,038.50, Z = −4.867, p < 0.001, \eta^2 = 0.061$. The average TOS of the third substitution in matches without extra time ($M_{TOS3} = 80.96, SD = 9.28$) was significantly lower than in matches with extra time ($M_{TOS} = 84.42, SD = 19.84$), $U = 6860.00, Z = −2.718, p = 0.007, \eta^2 = 0.061$. The average TOS of the second substitution in matches without extra time ($M_{TOS2} = 71.25, SD = 10.17$) was significantly lower than in matches with extra time ($M_{TOS} = 77.60, SD = 17.32$), $U = 6431.00, Z = −3.280, p = 0.001, \eta^2 = 0.061$. The average TOS of the third substitution in matches without extra time ($M_{TOS3} = 80.96, SD = 9.28$) was significantly lower than in matches with extra time ($M_{TOS} = 84.42, SD = 19.84$). The average TOS of the additional substitution in matches with extra time ($M_{TOS} = 106.38, SD = 7.83$).

### Table 2. Overview of the relevant data results from Study 2; comparison of the tournament (World Cup and DFB-Cup) matches with and without extra time.

| Variables       | Tournament Regular Time | Tournament Extra Time | Statistics |
|-----------------|-------------------------|-----------------------|------------|
| allowed substitutions | 3                      | 3 (+1)                | $p < 0.001, \eta^2 = 0.018$ |
| ØTOS [min of play] | 69.75 (SD = 14.96)      | 84.42 (SD = 19.84)    | $p = 0.007, \eta^2 = 0.061$ |
| ØTOS1 [min of play] | 57.93 (SD = 14.62)      | 63.78 (SD = 14.21)    | $p = 0.001, \eta^2 = 0.061$ |
| ØTOS2 [min of play] | 71.25 (SD = 10.17)      | 77.76 (SD = 12.16)    | $p < 0.001, \eta^2 = 0.061$ |
| ØTOS3 [min of play] | 80.96 (SD = 9.28)       | 91.51 (SD = 13.08)    | $\eta^2 = 0.061$ |
| ØTOS4 [min of play] | -                      | 106.38 (SD = 7.83)    |            |
| ØNS             | 2.94                    | 3.89                  | rISC = 32.31% |
| LRpS [min]      | 23.91                   | 38.87                 |            |
| rLRpS           | 2.56%                   | 3.15%                 |            |
| rLR             | 7.51%                   | 12.23%                | ILR = 26.08% |

1 added substitution for use in extra time. Note: TOS: times of substitutions; ØNS: average number of substitutions; LRpS: load reduction per substitution; rLRpS: relative load reduction per substitution; rLR: relative load reduction; rISC: relative increase of the substitution contingent; ILR: increase of load reduction.

The overall utilisation rate of the matches without extra time ($M_{UR} = 97.37\%, SD = 16.00\%$) did not differ from that of matches with extra time ($M_{UR} = 97.69\%, SD = 15.07\%$), $U = 106,587.00, Z = −0.262, p = 0.793, \eta^2 = 0.011$. The utilisation rate of the first three substituted
tions did not differ between matches ending in regular time \((M_{IR} = 97.37\%, SD = 16.00\%)\) and matches with extra time \((M_{ET} = 99.38\%, SD = 7.86\%\)), \(U = 78,579.00, Z = -1.566, p = 0.117, \eta^2 = 0.002\). The resulting average number of substitutions was 2.94 in matches ending in regular time and was 3.89 in matches ending after extra time. The relative increase of the substitution contingent was calculated to 32.31\% in Equation (8) and higher than the actual share of the added substitution in the substitution contingent (25\%). Therefore, the additional substitution in extra time was assessed as beneficial towards the tactical influence of coaches on the match.

The relative load reduction per substitution was calculated at 2.56\% in Equation (2), resulting in a relative load reduction of 7.51\% in Equation (3) for every match that ended in regular time. For matches with extra time, the relative load reduction per substitution was 3.15\%, resulting in a relative load reduction of 12.23\% per match. In comparison, the calculated increase in load reduction in Equation (7) indicated an increase of 26.08\% with the additional substitution in extra time for matches ending after extra time. Therefore, the increase in load reduction was lower than the calculated relative increase of the substitution contingent of 32.31\%, and the additional substitution in extra time was assessed as non-beneficial towards load reduction in one match.

The load reduction in matches with extra time per tournament was calculated to 3.30\% in Equation (6), resembling an increase of 22.17\% in load reduction compared to the load reduction for the entire tournament with a substitution contingent of three (2.70\%). This calculated relative increase of load reduction per tournament was lower than the calculated relative increase of the substitution contingent of 32.31\%. Therefore, the additional substitution in extra time was assessed as non-beneficial towards load reduction in a tournament.

6.2. Coaches’ Survey

Results of the coaching survey are displayed in Figure 4. The results of the questionnaire showed that coaches considered the current contingent of three substitutions in adult football as rather too few \((M_{Q3} = 2.081, SD = 0.759\) with a large effect size, \(t(24) = -6.058, p < 0.001, d = -2.473\).

Figure 4. Coaches survey: Mean of answers to questions three, four, and five on additional substitution in regular time. Note: * signals a significantly \((p \leq 0.05)\) higher mean value than the median (3.5), and + signals significant \((p \leq 0.05)\) higher mean value than the current substitutions contingent in regular time (3), and thus the assessment of the additional substitution with regard to the queried aspect as beneficial by the coaches.
In addition, the coaches assessed an additional substitution in extra time as beneficial with regard to a more frequent use of the first three substitutions ($M_{Q4.1} = 4.621, SD = 1.216$), $t(24) = 4.611, p < 0.001, d = 1.882$. On the contrary, the additional substitution was assessed as non-beneficial with regard to an earlier use of the first three substitutions ($M_{Q4.2} = 3.578$, $SD = 1.458$), $t(36) = 2.955, p = 0.005, d = 0.985$.

Coaches determined the additional substitution in extra time as beneficial regarding the aspects of load reduction in one match ($M_{Q5.1} = 5.12$, $SD = 1.216$), $t(24) = 6.663, p < 0.001, d = 2.720$, and load reduction in a tournament ($M_{Q5.2} = 4.520$, $SD = 2.395$), $t(24) = 2.129, p = 0.040, d = 0.869$.

The average size of substitutions contingent coaches would prefer was $4.240$ ($SD = 0.676$), and therefore, it was higher than the current substitution contingent of three, $t(24) = 9.177, p < 0.001, d = 3.747$.

7. Discussion

The results of the dual methodology from data analysis and subjective questionnaire indicate that an additional substitution in extra time is beneficial for the tactical influence of coaches on the match. The data indicate a theoretical increase of 33% and practical increase of 32% of the substitution contingent and, therefore, of the tactical influence of coaches on the match. Due to the already high utilisation rate of three substitutions in regular time, the utilisation rate objectively does not increase with an additional substitution in extra time. On the contrary, coaches indicate that the utilisation rate is influenced by the potential option to substitute again in extra time. Moreover, the coaches indicate that even more substitutions were desired.

Based on the evaluation of TOS, the results indicate that an additional substitution in extra time seems to be non-beneficial for load reduction in one match. On the contrary, the coaches clearly acknowledge the perceived benefit of the additional substitution in extra time. This discrepancy might be based on the later TOS of the first three substitutions of matches going into extra time. Coaches agreed that the additional substitution in extra time would not lead to earlier substitutions in regular time. This finding was probably caused by the fact that coaches tend to substitute later in close matches [9].

Therefore, an additional substitution in extra time seems to be non-beneficial for load reduction in a tournament. While the survey responses indicate that the coaches subjectively perceive this benefit, the data evaluation shows the opposite with an $ILR$ of 22%. Although there was a higher percentage of matches with extra time played compared to a regular club season, the ineffective use of substitution in close matches regarding load reduction resulted in later TOS and caused a lower $ILR$ than potentially possible.

8. General Discussion

In line with recent studies, our findings support the idea that an additional substitution would benefit the game [2,28,29]. The assessment of an additional substitution in regular time clearly indicates the potential for load reduction and an increase in the tactical influence of the coaches on the match. The benefits for the match day squad (including substitutions) were proven by an increase of the load reduction of 50%, and this value could be significantly increased if the substitutions were focussed on key players. The average time of the completion of the fourth substitution is at 81 min, with a utilisation rate of 70%. Therefore, coaches could take their key players off the field once the match has been decided, which will, in turn decrease the players’ load, and therefore, increase their recovery time and potentially their future performances.

However, the results of the two studies also show that the recent adoption of an additional substitution in extra time does not sufficiently fulfil the objective of reducing the load on players in a match, tournament, or season (see Table A1). While the added substitution definitely has the potential to reduce the player load crucially, the practical implementation showed that the coaches use this option too late in the games. Nevertheless, the coaches assessed the additional substitution in extra time as beneficial for load reduction
in a game but acknowledged its limitations for an entire season. As mentioned above, previous research and coaches’ responses in the survey indicate this was caused by the course of the match events. Contrary to an additional substitution in regular time, the first three substitutions would not be used earlier if the additional substitutions were only granted in extra time.

Based on the average timing of substitutions, especially the third substitution in adult football, substitutions are not optimally used to optimise regeneration. According to Bangsbo and Mohr [38], the recovery times of elite football players were about 89% longer in the last 15 min than in the first 15 min of a match, which results in a shorter recovery time for players who were substituted earlier. While this temporary fatigue may be caused by different physiological factors and not only by accumulated fatigue, it indicates that particularly late substitutions may not be beneficial in terms of player load reduction and recovery.

While these findings indicate that frequent substitutions can help maintain the health of athletes through squad rotation [28,29], other factors should not be neglected. As already mentioned, the amount of load players experience in relation to their rest time must be considered, especially among the national team players [30–32]. Therefore, it is critical to consider other variables such as the intervals between matches as well as the rest intervals between physical exercises while managing player load. However, while it is possible to regulate the intensity and load during training exercises, it is virtually impossible to do so in the matches. In such a scenario, additional substitutions offer the potential to better manage player load distribution even during matches.

When evaluating the dataset, it stood out that a high number of the possible substitutions was actually used. Nearly all (95%) of the possible substitutions in the Bundesliga were completed, and in 88% of the matches, all three substitutions were made, which points out to the necessity of the current rule. In line with the previous evaluations of the timing differences between matches with a substitution contingent of two and three [9], an increase in the substitution contingent would result in substitutions being made earlier and more frequently in the match. Even though only 70% of the fourth substitutions were used, the data still indicate that an additional substitution actually leads to a higher utilisation rate of the currently allowed three substitutions. This rapid decrease also indicates a potential threshold of the substitution contingent, after which the benefits of an additional substitution might become less pronounced. There are only a few other sports with a strict limitation of the substitution contingent as in football; in handball, for example, a fluid substitution of players throughout the match is possible. This leads to not only an increase in the intensity in matches but also an improvement in quality, which allows the players to maximise their performance level and ultimately increases the match’s quality as a whole. Further studies should investigate the optimal size of the substitution contingent or whether its limitation actually exists.

Limitations

The results of this study should be reviewed critically in order to correctly assess the realistic value of the findings. The theoretical basis for player load during a match was simplified for better comparison. Player load in football is characterised by highly intensive load such as sprints with and without the ball as well as jumps and long recovery periods [39]. Player load cannot be understood as a universally valid value in football [32]. Although we acknowledge the impact of match proceedings such as send-offs or the closeness of the match on player load and tactical coaching behaviour, we limited their role in this study to achieve the goal of a reliable overview for future rule changes. Therefore, the findings of the study give an indication on how valuable an additional substitution can be, but they are not applicable to one individual player’s or the team’s load reduction. Regarding the research question and general player load management by coaches, the methodological approach is highly valuable.
Due to the current regulations in football, a comparison of the times of substitutions with three and four substitutions in regular time was not possible within the same playing level. The highest youth league inputs indicate interesting insights into the potential benefits of an additional substitution, despite the different number of matches played and the lower level of intensity. Ideally, a test phase of an additional substitution at the top level should be implemented.

Previous studies allow the comparability of datasets between competitions by finding that neither the timing nor the tactics of substitutions are influenced by the level of competition [15,23].

9. Conclusions

The results of our studies illustrate the potential effects of an additional substitution in football. In theory, the additional substitution in regular time and extra time could be beneficial in terms of player load reduction in a game. They potentially enable almost 50% of additional load reduction in regular time and 27% in extra time. The implementation of these findings seems to be practicable, as the coaches’ responses and the data evaluation have shown. Moreover, an additional substitution both in regular time and in extra time could improve the tactical influence of the coaches on the match. While the potential benefits outweigh the possible negative impacts in practical terms, in practice, the implementation of the additional substitution in extra time confirmed the increase in the tactical influence of coaches on the match, but it did not show a benefit on overall load reduction for the players. The findings demonstrated the limits of the test phase with an additional substitution in extra time regarding the necessary long-term load reduction demanded by players, coaches, and sports scientists. In theory, it could have a positive effect on reducing player load in continental or World Cups. However, the analysis of the TOS showed that in the matches that went into extra time, substitutions were made later, and thus, the reduction in player load was less. Findings of both studies implied that the load reduction achieved by this approach is not sufficient over the course of one season.

On the other hand, the current findings suggest that an additional substitution in regular time can be of far more value for a club, as a significant load reduction can be achieved. However, because of restrictions due to the current rules, the comparability of the two analysed datasets is limited. Therefore, our two case studies yield information about the potential effects of an additional substitution in football on load reduction and the tactical influence of coaches on the match and clearly point out the necessity for further studies that should ideally include the data of a test phase with four substitutions in regular time and one in extra time.

The novel methodology used in this work was the best possible option available to indicate the effects of an additional substitution in football, because of the unavailability of data for direct comparison player load assessment. The findings of this study clearly indicate the potential of an additional substitution in regular time and the implications of the additional substitution in extra time. The findings should help plan for a test phase of the additional substitution in order to assess the effects on load reduction more accurately.

**Author Contributions:** Conceptualisation, J.M. and S.K.; methodology, J.M.; validation, J.M. and S.K.; formal analysis, J.M.; investigation, J.M.; resources, S.K.; data curation, J.M.; writing—original draft preparation, J.M.; writing—review and editing, J.M. and S.K.; visualisation, J.M.; supervision, S.K.; project administration, S.K. Both authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Raw data were generated at the lead institution. Derived data supporting the findings of both studies are available from the first author (J.M.) on request.
### Acknowledgments
We want to thank Christian Baumgart for his dedication to data collection.

### Conflicts of Interest
The authors declare no conflict of interest.

### Appendix A

![Graphical representation of the linear increase of player load development during an observed match.](image)

**Figure A1.** Graphical representation of the linear increase of player load development during an observed match.

| Variables | Bundesliga | U-19 Bundesliga | Tournament Regular Time | Tournament Extra Time |
|-----------|------------|----------------|------------------------|----------------------|
| allowed substitutions | 3 | 4 | 3 | 3 (+1) \(^1\) |
| ØTOS [min of play] | 71.25 | 67.03 | 69.75 | 84.42 |
| ØTOS1 [min of play] | 56.45 | 51.78 | 57.93 | 63.78 |
| ØTOS2 [min of play] | 72.96 | 65.86 | 71.25 | 77.76 |
| ØTOS3 [min of play] | 83.02 | 74.19 | 80.96 | 91.51 |
| ØTOS4 [min of play] | - | 80.95 | - | 106.38 |
| ØNS | 2.86 | 3.60 | 2.94 | 3.89 |
| LRpS [min] | 22.15 | 26.37 | 23.91 | 38.87 |
| rLRpS | 2.37% | 2.82% | 2.56% | 3.15% |
| rLR | 6.79% | 10.15% | 7.51% | 12.23% |

\(^1\) added substitution for use in extra time. Note: TOS: times of substitutions; ØNS: average number of substitutions; LRpS: load reduction per substitution; rLRpS: relative load reduction per substitution; rLR: relative load reduction; rISC: relative increase of the substitution contingent; ILR: increase of load reduction.

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