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Effects of a 10-Week Athletic Performance Program (APP) on Match Performance Variables in Professional Football Players

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Abstract: The aim of this study was to evaluate the effect of an Athletic Performance Program (APP), performed in addition to teams' regular training routines, on match performance variables in professional football players. Twenty-nine professional football players (age=27.21±4.95 years; body mass=79.56±5.21 kg) of the Spanish First Division (*LaLiga*) underwent a 10-week training program focused on the development of mobility, stability, strength, and multidirectional running skills. The APP included 5 indoor sessions per week and on-field micro-dosing stimulus in addition to regular training practices. Match performance variables obtained with GPS devices during official matches and jump performance were measured before and after the APP. The APP increased peak running speed (31.1±1.4 vs 32.1±1.0 km/h, P < 0.001, *d*=1.88), the number of sprints (0.14±0.03 vs 0.16±0.03 sprint/min, P< 0.001, *d*=1.44) and the sprint distance (6.45±1.43 vs 8.35±1.22 m/min P< 0.001, *d*=2.49) during the matches. The intervention also increased countermovement jump height (34.1±2.7vs 35.8±2.5 cm, P< 0.001, *d*=2.20). The APP was effective to improve intense actions during competitive match play in professional football players. Strength and conditioning coaches may consider the use of multicom-ponent physical training programs included in the usual training week to enhance players' match running at high intensity.

Keywords: elite athlete; conditioning; soccer; mobility; stability; performance

1. Introduction

Football is a complex team sport characterized by the repetition of high-intensity actions interspersed with recovery periods of lower exercise intensity. Physical abilities associated with repeated sprinting, accelerating, jumping, and changing direction are essential contributors to the potential performance of football players (Oliva-Lozano, Fortes, Krustrup, & Muyor, 2020; Pareja-Blanco, Asián-Clemente, & Sáez de Villarreal, 2021). At the elite level, players may be involved in more than 60 competitive matches (Lago-Peñas, Rey, Lago-Ballesteros, Casáis, & Domínguez, 2011) over the course of a ~45-week season. This means that professional players are exposed at least to one match per week while there are specific times of the season when multiple matches are played within the same week (Ranchordas, Dawson, & Russell, 2017). This demanding calendar produces that the training schedule of professional football teams is used mostly used to ensure recovery between matches, troubling the provision of an appropriate physical training stimulus during the training week. In addition, professional football teams devote a considerable amount of training time to develop tactical actions on the pitch to prepare against the characteristics of the next rival, further limiting the time employed to condition players for the physical demands of the game. From a practical standpoint, there might be a need to implement more specific physical training programs to enhance the preparation of professional football players (Oliva-Lozano et al., 2020; Pareja-Blanco et al., 2021) beyond the traditional routines developed on the pitch. These training programs should be focused on the development of players' physical performance while ensuring an adequate

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provision of recovery between matches. For this reason, physical training programs performed in addition to team tactics exercises should be individualized and take into account player's involvement in previous matches.

The addition of strength/power training programs to routine football training may favor a more integral physical fitness development of the player (Silva, Nassis, & Rebelo, 2015). The associated improvements in performance parameters (e.g., jump, sprint, COD performance) potentially achieved with the strength training activities may increase a player's ability to cope with training and competition demands (Silva, Nassis, & Rebelo, 2015). The inclusion of training activities to develop other training capacities is also necessary to optimize in-season player's performance as not only strength values are affected by the season (Kraemer et al., 2004). Other variables such as ankle (Moreno-Pérez et al., 2020) or hip range of motion (Víctor Moreno-Pérez et al., 2022) decrease along the season. Restoring joint range of motion through mobility exercises has previously shown benefits in football players such as increased acceleration and running speed (Baron, Bieniec, Swinarew, Gabryś, & Stanula, 2020; Hung, Chung, Yu, Lai, & Sun, 2019; Lopez-Samanes et al., 2021). Last, it seems that adding training sessions of high-intensity interval training (HIIT) in addition to in-season training may increase aerobic performance and maximal running sprint (Dupont, Akakpo, & Berthoin, 2004)(Wells, Edwards, Fysh, & Drust, 2014). Collectively, all this information suggests that a multicomponent physical training program performed in addition to normal football training routines may favor several aspects of football performance. However, the literature about the efficacy of multicomponent training programs is scarce and no investigation has measured the utility of this type of training on performance during match play. Hence, the aim of this study was to evaluate the effect of a customized Athletic Performance Program (APP), consisting of mobility, stability, strength, sprint micro-dosing abilities and multidirectional and linear running skills, and performed in addition to teams' regular training routines, on match performance variables in professional football players. We hypothesised that the APP would lead to an increase in match performance variables and will be critical to reach the final stretch of the season with improved variables.

2. Methods

2.1. Participants

From an initial potential sample of 34 players, 29 football players completed all phases of the study. Three players were discarded due to injury within the intervention for causes unrelated to the study and 2 decided to drop the experiment. Participants had to meet the following criteria: (*a*) professional football player (>18 years) with no history of cardiovascular o metabolic pathologies and having no injuries during the process of the investigation. (*b*) no musculoskeletal injury in the month prior to the onset of the investigation. Players with a history of knee surgery were also excluded from the study. The 29 players completing the experiment (age = 27.21 ± 4.95 years; height = 183.16 ± 5.25 cm; mass = 79.56 ± 5.21 kg) were professional players from a team competing in the top division of Spanish football (LaLiga). Among these players, 12 were defenders, 10 were midfielders and 7 were forwards. On average, players trained 16 hours per week and took part ~1 match per week over the season. All participants provided written informed consent, and procedures were conducted according to the Declaration of Helsinki. The entire data collection procedure was approved by the ethics committee of the Universidad Rey Juan Carlos (Spain).

2.2. Study design

A prospective quasi-experimental study was designed to determine the effect of a 10-week Athletic Performance Programme (APP) focusing on mobility, stability, strength, sprint micro-dosing abilities and multidirectional and linear running skills on match performance variables in professional football players (Figure 1). Participants underwent the APP in addition to their normal on-field training routines. The programme included 5 weekly sessions and each session lasted 30 minutes. In addition, micro-doses of field training were applied between weeks 6 and 10 of the

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programme, exclusively on MD-3 days, namely with acceleration-sprinting on uphills and with repeated 40+40 m sprints.

The APP was agreed and scheduled with the approval and supervision of the team's coaching staff. Before and immediately after the training programme, performance variables were measured in official matches to certify the potential effectiveness of the programme. Data were collected for three consecutive seasons (2019-2020; 2020-2021; 2021-2022) with team players who met the inclusion criteria. During these three seasons, the team's strength and conditioning staff was the same and data were collected between October and November for the pre-intervention measurement (once the team had played 6-8 official games) and in February to April for the post-training measurement. In that sense, previous studies used similar measurements with athletes (Jiménez-Reyes, Garcia-Ramos, Párraga-Montilla, Morcillo-Losa, Cuadrado-Peñafiel, Castaño-Zambudio, Samozino & Morin, 2022).

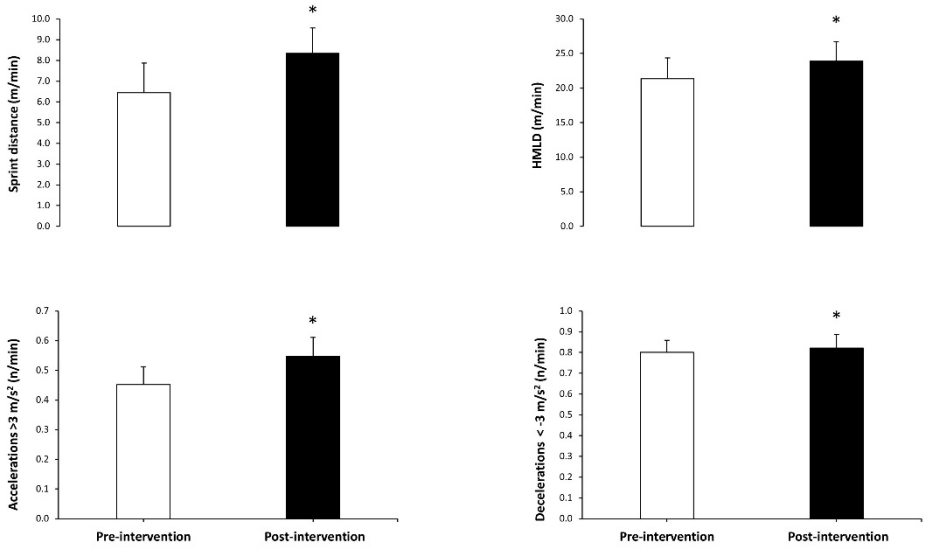

Figure 1. Sprint distance, high metabolic load distance (HMLD) and number of accelerations and decelerations during 4 official competitive matches before (pre-intervention) and after (post-intervention) a 10-week Athletic Performance Program with mobility, stability, strength, and multidirectional and linear running skills. COD: Change of direction; MD: Match Day; BW: Body Weigth; Plyo: Plyometric; Acc: Acceleration;.

2.2.1. Athletic Performance Programme (APP).

The APP consisted of a set of exercises focused on the development of mobility, stability, strength, sprint ability drills and multidirectional and linear running skills and was performed indoor and too with some exercises on-field, between weeks 6 and 10 of the programme on MD-3 days with uphill drills of 6x18m (weeks 6-8) and 8x18m (weeks 9-10) at maximum speed and 6x(8+8 efforts of 40m) between weeks 7 and 10 of the programme, also on MD-3 days. The APP lasted 10 weeks.

In each week, the structure was the same (Table 1 & Supplementary material 1) taking into account the last competitive match. The training days were either focused on recovery and developing mobility and stability (performed on Matchday +1 and Matchday +2 and Matchday -2), on developing lower limbs muscle strength (performed on Matchday -4) and on enhancing multidirectional, linear running performance and micro-dosing sprint (performed on Matchday -3). Between weeks 6 and 10 of the programme, these micro-doses of training focused on accelerations and sprints in the field were applied. Other studies have also applied this micro-dosing concept to assess sprint performance enhancement (Cuadrado-Peñafiel, Castaño-Zambudio, Martínez-Aranda, González-Hernández, Martín-Acero & Jiménez-Reyes, 2023).

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The APP had a daily undulating periodization from the perspective of the weekly microcycle (Gavanda, Geisler, Quittmann, & Schiffer, 2019). The APP was individualized and take into account the time match play of each player in the prior competitive match. In the weeks with more than one competitive game, only training days with a focus on recovery/mobility/stability were applied for players that completed the games, while a normal training week was performed by those players with less than 30 min of match play (i.e., substitutes).

Table 1. Weekly structure of the 10-week Athletic Performance Program (APP) with mobility, stability, strength, and multidirectional and linear running exercise.

Main objective	Recovery	Strength	Running drills
Days	MD +1 MD+2 MD-2	MD -4	MD -3
Exercises	Mobility & stability exercises	Strength indoor exercises	Multidirectional and linear running drills

MD: Matchday.

Specifically, the recovery/mobility/stability days were focused on enhancing the ranges of motion (ROM) of the thoracic spine, hip and ankle and achieving optimal development of lumbopelvic control. The main methods used were exercises that included the use of foam rollers and elastic bands for joint distraction (Guillot, Kerautret, Queyrel, Schobb, & Di Rienzo, 2019; Yoshimura et al., 2021). Stability and motor control exercises were also used in the recovery/mobility/stability days to enhance the between the muscles of the trunk to stabilize the pelvis (Hibbs, Thompson, French, Wrigley, & Spears, 2008; Lee, 2021; Pyka, 2017), the glutes to improve knee stability (Sebesi et al., 2021), and hip muscles exercises to integrate the movement with the lower limbs (Mausehund, Skard, & Krosshaug, 2019). The training days focused on the development of lower limb muscle strength were planned to follow a daily-undulating programming (DUP) and a block periodization (Stone et al., 2021). For this purpose, the first 4 weeks had an emphasis on the development of maximal strength with a greater residual effect (Issurin, 2016), followed by 2 weeks focused on preparing the tissue for more demanding high-velocity forces that were included in the last 4 weeks, with a power emphasis. Last, the training days focused on running tasks included exercises to develop lineal & multidirectional running mechanics including sprint technical drills and resisted sled training (Petrakos, Morin, & Egan, 2016) with intending to improve the application of forces during running (Haugen, McGhie, & Ettema, 2019; Schuermans, Van Tiggelen, Palmans, Danneels, & Witvrouw, 2017). In these days, plyometric training was also included to maximize the use of elastic energy and reduce contact time (Miyashiro, Nagahara, Yamamoto, & Nishijima, 2019). Finally, the stimulus with micro-dosing sprint was applied (Cuadrado-Peñafiel et al 2023).

2.2.2. Match performance variables and jump height

GPS match variables

Match performance during official matches was recorded by the GPS-accelerometer units (WIMU PRO™, Real Track Systems®, Spain). The GPS devices obtained data with a frequency of 18 Hz. According to the manufacturer's recommendations, all the devices were positioned inside a vest and were activated in the middle of the football pitch 15 min before data collection to allow the acquisition of satellite signals and synchronization of the GPS clock with the satellite's atomic clock. Match performance was collected from 4 official matches carried out just before and after the training program. To be considered, the matches should be carried out within the month prior to or after the intervention, and the players had to play at least 80 min in each match. Following each match, data were downloaded to a personal computer and analyzed using a customized software package SPROTM. The variables obtained with the GPS-accelerometer units were: a) Total running distance (m/min); b) High Speed Running Distance (HSRD) which was the distance covered at > 21km/h

(m/min); c) accelerations > 3m/s2 (number/min); d) decelerations < -3m/s2 (number/min); e) High metabolic load distance (HMLD) which was the distance covered at > 25.5 W/kg (m/min); f) peak speed (km/h); g) number of sprints (number/min), taking into account that one sprint was defined as a running action performed at > 24 km/h and covering at least 5 m (Andrzejewski, Chmura, Pluta, Strzelczyk, & Kasprzak, 2013). All variables were normalized by the player's match time (except for peak running speed) as the match duration was not the same in all matches.

Vertical Jump Test

A maximal countermovement jump (CMJ) was performed the week before and the week after the APP, at least 72 h the prior competitive match. CMJ height was measured with the MyJump 2 App, following the instructions of (Gallardo-Fuentes et al., 2016). For the CMJ execution, the player was instructed to rest his hands on his hips while performing a downward movement followed by a maximal effort vertical jump. All players were instructed to reach the maximal height and to land in an upright position, bending the knees after landing. Three CMJs were completed after a short warm-up consisting of 5 min of running, 5 mobility exercises and 4 lumbopelvic exercises, and submaximal jumps. There was a 60-second rest between each jump. The mean of the 3 trials was used for subsequent analyses

2.3. Statistical Analysis

All statistical analyses were carried out in the v27.0 of the SPSS software (IBM, USA) while the figures have been designed in Excel spreadsheets (Microsoft, USA). Initially, the normality of each variable was checked with the Shapiro-Wilk tests. Since all variables were normally distributed (P > 0.050), parametric tests were selected to examine differences between pre- and post-intervention values. Student's t-tests for paired samples were used to detect differences between pre- and post-intervention values and the percentage of change was calculated for each variable. Cohen's formula for effect size in paired samples (d) was used for comparing differences pre- and post-intervention and the magnitude of the size was interpreted as follows: trivial (d = 0–0.19), small (d = 0.20–0.49), medium (d = 0.50–0.79) and large (d = 0.80 and greater). The significance level was set at P < 0.050. Data are presented as means and standard deviation.

3. Results

In comparison to before the intervention, the total running distance covered during the official matches increased by 4.9 ± 3.5% after the intervention (P < 0.001, d = 1.42; Table 2). The peak running speed reached during the matches was also increased after the intervention by 3.4 ± 2.0% (P < 0.001, d = 1.88) along with a higher number of sprints per match (P < 0.001, d = 1.44; Table 2). The intervention also increased the sprint distance (↑31.2 ± 15.9%, P < 0.001, d = 2.49; Figure 1), the HMLD (↑12.5 ± 7.1%, P < 0.001, d = 2.20), and the number of accelerations (↑20.1 ± 8.7%, P < 0.001, d = 2.48) and decelerations (↑2.3 ± 3.8%, P = 0.003, d = 0.61) performed during official matches when compared to pre-intervention values. Finally, the intervention increased the jump obtained during the CMJ (P < 0.001, d = 2.20).

Table 2. Running performance variables during 4 competitive matches and jump height before (pre-intervention) and after (post-intervention) a 10-week Athletic Performance Program with mobility, stability, strength, and multidirectional and linear running skills.

Variable (units)	Pre-intervention	Post-intervention	Δ (%)	P value
Total running distance (m/min)	117.6 ± 5.0	123.1 ± 3.5	↑ 4.9 ± 3.5	< 0.001
Peak running speed (km/h)	31.1 ± 1.4	32.1 ± 1.0	↑ 3.4 ± 2.0	< 0.001
Number of sprints (n/min)	0.14 ± 0.03	0.16 ± 0.03	↑ 17.6 ± 14.1	< 0.001
CMJ height (cm)	34.1 ± 2.7	35.8 ± 2.5	↑ 5.6 ± 2.9	< 0.001

CMJ: Countermovement Jump.

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4. Discussion

In professional football, maintaining players' physical condition through the season is one of the main aims of the strength and conditioning staff during the competitive period (Meckel, Doron, Eliakim, & Eliakim, 2018). This is because the complex competitive schedule of professional football entails several competitions with at least one match per week, producing that, for most elite football players, the matches suppose the main training stimulus within the week. In this context, the training week is developed to recover from the previous match and to prepare the players for the following match, with very limited time devoted to enhancing physical performance. Additionally, the coaching staff must conjugate multiples objectives for the training practices available such as the preparation of the strategy, the improvement of individual technical-tactical skills, and psychological preparation (Haugen, Tønnessen, Hisdal, & Seiler, 2014; Meckel et al., 2018) which further limits the time available for performance development. Collectively, these characteristics of professional football frequently impede the existence of a proper conditioning program during the season (Oliva-Lozano et al., 2020; Pareja-Blanco et al., 2021). In this context, the aim of this study was to evaluate the effect of a customized Athletic Performance Program (APP) added to the regular training routines on match performance variables in professional football players. The study was developed within a professional football team to increase the ecological validity of the study outcomes. Overall, the APP increased players' peak running speed, the number of sprints, and the ability to accumulate sprint distance during matches which constitutes remarkable proof of efficacy for this training program. These outcomes suggest the utility of including personalized physical preparation programs as an addition to traditional on-pitch football training practices to enhance players' match running performance at high intensity. In this context, strength and conditioning coaches may consider the use of mobility/stability, strength exercises and running tasks to complement players' physical condition, particularly in professional football teams with difficulties to reach a proper training stimulus due to the demands of the calendar.

In comparison to the assessment performed before the intervention, the 10-week APP improved high-intensity running performance (i.e., peak speed, sprint distance, number of sprints and HMLD -m/min- and total distance covered) during competitive matches and has a positive influence on mechanical variables such as the number of accelerations and decelerations. The improvements in these variables were statistically significant and meaningful in terms of sports performance as the magnitude of the improvements ranged from 2 to 31%. The wide range and the magnitude of the effects induced by the APP were likely produced by the characteristics of the program, which included 5 × 30-min sessions per week with training days focused on mobility/stability, strength and running performance. Interestingly, other specific programs applied to professional football players with 1 session/week of strength training for 12 weeks were effective to maintain strength, sprint, and jump performance achieved during a preceding 10-week preparatory period but did not report enhancements on these variables (Rønnestad, Nymark, & Raastad, 2011). Additionally, previous studies (Dupont et al., 2004) observed that professional players who performed two HIIT sessions in addition to in-season training increased maximal aerobic speed while reducing the time to complete a 40-m sprint. Collectively, all this information suggests that at least two sessions of physical conditioning, added to the usual training routines of the team, is needed to produce improvements in key physical parameters. The current investigation is innovative because included a multicomponent training program and because the efficacy of the program has been measured during competitive matches, instead of the use of running and jump tests. The improvements in the current investigation provide by the APP program could be attributed to a multifactorial nature (Mujika, Halson, Burke, Balagué, & Farrow, 2018). Mobility and stability exercises were included for better joint stacking which could lead to more efficient movement during running at high intensity (Lahti, Mendiguchia, Edouard, & Morin, 2022; Mahdieh, Zolaktaf, & Karimi, 2020). Strength and power exercises were included due to the ample evidence that certifies their usefulness in improving several aspects of sports performance (Held, Speer, Rappelt, Wicker, & Donath, 2022). Last, linear and multidirectional running exercises were added to implement more automated movement mechanics during accelerating and sprinting (Donelon, Dos'Santos, Pitchers, Brown, & Jones, 2020).

Although the current study impedes disaggregating what contribution each type of training had on the enhancement of match running performance, the current study reveals that a multicomponent training program can produce significant improvements in football-specific physical capacities.

After the APP, participants improved running distances at high speed and at high metabolic load, together with an enhanced capacity to accelerate and decelerate and improved jump performance. The obtaining of such improvements was likely propitiated by the type of exercises and the progression of intensity, implemented by 5 × 2 weeks block for the 10-week duration of the APP. For example, the APP included sprint micro-dosing technical drills and resisted sled training for the training day focused on enhancing running performance (Petrakos et al., 2016). We hypothesize that this type of training was the main responsible for the enhancement of running parameters during the match as they have been found to enhance the application of forces during sprinting (Haugen et al., 2019; Schuermans, Danneels, Van Tiggelen, Palmans, & Witvrouw, 2017). The training days devoted to recovery/mobility and stability were more oriented to restoring player's physical capacity after the prior competitive match, but it is likely that these days also contributed, in an indirect manner, to the improved running performance during the matches, through a better range of movement at different joints (López-Valenciano, Ayala, De Ste Croix, Barbado, & Vera-Garcia, 2019). Likewise, the program included plyometric exercises with vertical and horizontal vectors at high speeds which were probably linked to the improved player's acceleration/deceleration profile during the match and better jump performance, as these type of exercise has marked effect on the characteristics of force development-absorption during short-and intense exercise actions and could affect the nature of the adaptive response (Suchomel et al., 2019). From a practical standpoint, the use of a physical training program that included several types of exercise -developed during different days- may be more effective than the use of a single-component type of training (e.g., high-intensity intermittent training) as the characteristics of football patterns require players not only to run at high speed but to accelerate in short spaces without the obtaining of high speeds and constant changes of direction.

The current study possessed some limitations that should be discussed to contextualize the application of the study. First, there was no control group to assure that the gains presented in the current study were the result of the APP instead of the normal evolution of players' physical condition during the season. The use of a control group was not feasible in the context of a professional football team as this would imply that some professional players would have performed less training than other teammates. However, previous data indicate that player's match performance is maintained constant through the season once players have completed the first 6-8 matches (Brito de Souza, López-Del Campo, Resta, Moreno-Perez, & Del Coso, 2021; de Souza et al., 2021). For this reason, we included the pre-training measurement in October, after players had played 6-8 competitive matches. In this context, players had likely reached their steady-state match performance and we honestly believe that the improvements obtained in this study on match performance variables are the result of the APP and they did not reflect in-season changes in performance. Second, this study was performed in a professional football team with a complex competitive calendar. It is possible that other football teams of lower categories do not need to implement APP as a less congested calendar allows the development of training week with more time to develop players' physical conditioning. Last, we only study a multi-component APP with mobility, stability, strength, and multidirectional and linear running skills-based tasks and we are unable to determine what components of the APP were responsible for the improvements found in this study. Despite these limitations, we honestly believe that the study outcomes may be of great utility for strength and conditioning coaches of professional teams with complex competitive calendars.ç

5. Conclusions

The inclusion of a multicomponent 10-week training program focused on the development of mobility, stability, strength, sprint abilities, multidirectional and linear running skills in the usual training program was effective to improve intense actions during official match play in professional

football players. These outcomes suggest that the addition of a customized and personalized physical training program to the traditional training week of professional football teams may be an effective strategy to improve players' high-intensity running during competitive matches. Coaches and strength conditioning staff are continuously looking for the best training approach to optimize professional football players' performance within the context of the congested calendar that intrinsically accompanies professional football. For this reason, the staff of professional football teams may consider the use of multicomponent training program as an addition to traditional pitch football training to enhance players' match running performance at high intensity.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org.

Author Contributions: Conceptualization: S.J.R.-J.L.E; methodology: S.J.R.-J.L.E. and J.D.C; software: S.J.R.-V.E.G. and S.L.J.; validation: S.J.R.-J.D.C. and S.L.J.; formal analysis: J.D.C.; investigation: S.J.R.-J.L.E. and V.E.G.; resources: S.L.J.; data curation: J.D.C.; writing—original draft preparation: S.J.R. and J.D.C.; writing—review & editing: S.J.R.-J.D.C.-J.L.E.-V.E.G. and S.L.J.; visualization: S.J.R. and J.D.C.; supervision: J.D.C. and S.L.J.; project administration: S.J.R.; funding acquisition: S.J.R. All authors have read and agreed to the published version of the manuscript.

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