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RESEARCH ARTICLE

Enhancing Untrained Football Referees' Strength, Speed, and Endurance through A Mix-training Programme

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Abstract
Given the distance, energy consumption and football referees' physical challenge during matches, it is crucial that their speed, endurance, and strength should be enhanced. It is in this perspective that this One-Group Pretest-Posttest Design quasi-experimental research, aims to (a) validate a mixed-training program to enhance Primus League football referees' speed, endurance, and strength. The research also aims to (b) gather evidence on the program reliability and effectiveness. The sample consisted of 15 Primus League football referees (n=15) who attended a five-week training program with sessions held 3 times per week. During an expert panel, eight Fitness and Vitality Enhancement (FVE) professionals validated the program and later the replicability estimation indicated the training program related tests' high reliability (ICC=0.77). The normality assumption was verified, and the results obtained through paired-sample t test, with related sig.<0.025, indicated that the intervention program effectiveness, except the speed component for which there was not enough evidence of the referees' improvement. With bigger sample sizes, it is recommended that the relation between the referees' age, body mass, and speed be established to shed light on the reason of speed component statistical insignificance.

Keywords
Mix-Training Program, Paired-Sample T Test, Speed, Endurance, Strength, Football Referees

INTRODUCTION

Football referees require specialized training to perform optimally during matches, (Abdula, et al., 2022). There are scientifically evidenced reasons they should train for strength, speed, and endurance as main aspects for which immediate intervention is crucial for untrained Burundian football referees, (Kabadayı, et al., 2021). The existing literature points out that football referees should be trained and best methods to achieve effectiveness in training some of aspects like sprinting and changes of directions, strength, speed, agility, endurance, and cardiovascular fitness, nutrition, and then hydration, (Oybek o'g'li, 2023).

But of those aspects for which football referees should be trained, three have held the world of researchers' attention: the football referees' strength, speed, and endurance, (Kusumah, et al., 2022). Indeed, the existing literature point out that these aspects play a crucial role in ensuring that referees can effectively officiate football match events; but Bouzas-Rico, et al., (2022) focused on the referees' physical fitness. But Castillo, et al., (2016) observed that physical fitness may contribute but cannot be viewed as unique or the most essential factor determining football referees' effectiveness.

To begin, football referees' strength training is very crucial: it is believed that a whole football

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match climax into almost 12 km that a referee covers during a single match, (Aoba, et al., 2011; Barbero-Álvarez, et al., 2012). On the one hand, strength is a fundamental attribute for football referees, (Slack, et al., 2014). Officiating a football match requires a strong physical resilience as sometimes such referees can have recourse to high-speed running, (Brady, et al., 2023). During a match, a referee's physical demands are significant, and strength helps in withstanding match plays. By improving overall strength, referees can better handle the physical challenges they encounter during their duties of officiating football matches, (Weston, et al., 2012; Sarıca, & Gencer, 2024).

On the other hand, research has shown that the referee's strength resilience helps prevent unnecessary Injuries. Strength training enhances stability and reduces the risk of injuries. Referees who engage in exercises targeting strength and stability are less likely to suffer injuries, allowing them to perform better and move more efficiently, (Castillo, et al., 2016).

Although not seemingly directly related, it was scientifically proven that a football referee's strength is statistically significant with control and decision-Making. Recent studies demonstrated how referees' physical fitness significantly influences their decision-making through the match, (Pizzera, et al., 2022; Castillo-Rodríguez, et al., 2023). This brings in an argument that a referee's strength contributes to better control over a match during refereeing. Referees need to exert authority and make split-second decisions.

A strong physical foundation enables them to maintain focus and handle game situations effectively, (Helsen, MacMahon & Spitz, 2019; Samuel, Tenenbaum & Galily, 2021). In their effort to nurture decision-making among football referees, Schweizer, et al., (2011) suggested the use of video as an intervention for those referees; the authors observed that such a method could cultivate referees' intuitive decision-making skills.

As far as football referees' speed training is concerned, there is logical reason for speed training, (Pizzera, et al., 2022). One of the effectiveness of a football refereeing is positioning: for accurate decision that might arise any moment, during a match a football referee needs to be in the right place at the right. So, speed training allows referees to quickly move across the field, which ensures that they have a clear view of player actions and incidents, (Johansen & Erikstad, 2021). That is why speed is crucial for referees to keep up with the game and position themselves optimally. To some level though, positioning and running were found not always to correlated with football referees' accurate decision-making, (Riiser, et al., 2019). There are many other factors affecting accuracy in decision making when refereeing or officiating a match.

Some researchers observed that the football referee's movement pattern resembles that of players "without the ball". They cross the field to stay close to the action, covering approximately the same distance as players. If they would have flows in their speed, this would be a blow on maintaining proximity to the ball possession, thus failing to manage game situations effectively, (Monea, et al., 2019).

Another aspect that is critical for football referees is endurance. Training for football referees on aspects that sustain their endurance is very crucial. It ensures that football referees can consequently maintain their optimal endurance the match as research has shown that a referee runs up to 10,000m through one match, (Reilly and Gregson, 2006). Together with a minimal match duration of 90 minutes, call for their endurance is very recommended. There is test like the Yo-Yo intermittent test level 1 referees' trainers can use to see their performance, (Monea et al., 2019).

As it can be seen, referees have similar workload as players running approximately the same distance as players although in different movement patterns. Understandably then, endurance training prepares football referees to sustain effort through matches, bringing them up to the point of keeping up with play and manage game situations by coordinating speed and endurance, (Blumenstein & Orbach, 2014; Sánchez-García, et al., 2018). Endurance training enable match referees' fatigue management, which ensures that they remain alert and capable of keeping eyes on the game during intense moments.

The main problem is that Burundian football referees officiate matches without any related training either in endurance, speed, and strength. Given how the existing literature linked these aspects with decision-making, one might doubt on the accuracy of decisions made during matches. What is more, an assumption may also nourish an enlightened mind that the cases of repetitive referees' injuries are linked to lack of training on the three aspects mentioned above.

A quick intervention on training football referees in Burundi is very crucial. This research aims at:

Validating a mix-training programme for Burundian football referees;

Testing the developed mix-training programme's effectiveness for Burundian football referees

Based on the research objectives, the guiding question are the following:

How valid and reliable is the mix-training programme for Burundian football referees?

What is the evidence proving the mix-training programme effectiveness for Burundian football referees?

MATERIALS AND METHODS

Participants

The research population is all the academically trained football referees officiating Primus League matches in Burundi football competitions. The non-probabilistic sampling method was used, and the convenience sampling technique allowed us to select only n=15 research sample size of football referees from the Primus League Burundi living in the city of Bujumbura and who take a single bus from their home to the training field, (Dilek, 2022).

This research has met ethical rules. Research ethical approval was obtained Research Ethics Committee with project number 021/REC/2024. Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

Data collection Instruments

The research instrument consisted of physical test series taken before each Fitness and Vitality Enhancement (FVE) session. So, the data consisted of results from a series of those physical tests carried out at the beginning (pre-test) and at the end of the intervention (post-test). The referees attended the program 3 times a week for 5 weeks.

Research Design and Data Analysis

This is quasi-experimental research with "One-Group Pretest-Posttest Design", (Mertens, 2023). Technically, the design is O X O with:
O: referees' speed, endurance, and strength
X: the mix-training program
O: referees' speed, endurance, and strength after intervention

In this research, referees' speed, endurance, and strength are measured both before and after the mix-training program, the treatment of interest in this study, (Mertens, 2024).

As far as data analysis technique is concerned, the descriptive statistics were used, and the paired-sample t test was computed by the help of RStudio 2024.04.

Physical Test Reliability

The best shot to begin this research result display is about the reliability index. Using the intraclass correlation for the means vectors for the pretest and post-test:

```
> icc_result$value
[1] 0.7749183
```

The item reliability is 0.77, which is higher the conventional cutoff score of 0.7 for reliability index. With the ICC of 0.77, there is an indication of the physical education test replicability .; if the same process of the quasi-experimental research were to be repeated on a sub-sample football match officiating professionals, similar results would be obtained.

Content Validity

The validation process of the mix-training program for the academically trained football referees was done through expert judgement using the Focus Group Discussion (FGD) data collection instrument. Eight (8) experts attended the discussion and the quasi-experimental researchers made presentation about the training content. Based on their expertise in the field, the experts asked questions and suggested improvement of the training content in the very session. The researchers included the expert judgement recommendation and the results of the FGD are tabulated in Table 1 below:

Table 1: Content validity

No	Training Component	Observation after FGD
1	Speed	Valid
2	Endurance	Valid
3	Push -ups	Valid
4	Leg Curl 10KG	Valid
5	Leg Press 45KG	Valid
6	Leg Curl. A/3Min (10KG)	Valid

Table 1 shows that following experts' suggestions for revision during the FGD, all the

mix-training components or content became 'valid'. Since they were validated by experts with renowned experience in physical fitness building intervention for various sports professional categories, the mix-training content were wrapped into this intervention for Primus League match officiating professionals.

Normality Assumption Test

The normality assumption is integrated in the paired t test complete information with lessR RStudio package. It yields out for normality assumption, inference, effect size and two plot, that is, the One-Group and Differences from Equality plots. Given the nature of Physical Test components, mean values are used and not the actual observations. The data used then are the combination of means for the pre-test and post-test on components such SP, END, PUSH LEGCU10K, LEGPRES45K, and LECURLA3M10K.

Below is the normality assumption tested:

H0: The pretest-posttest difference scores is not normally distributed (if p-value < 0.05, accept the H0)

Ha: The pretest-posttest difference scores is normally distributed (if p-value associated with W is ≥ 0.05, there is not enough proof to accept the H0, we assume that the difference scores is normally distributed; we accept the Ha)

The lessR package code line used is:

> ttest(pretest_mean_vector, posttest_mean_vector, data=data, paired=TRUE:

Shapiro-Wilk normality test: W = 0.8054, p-value = 0.066

The p-value is 0.066, which is >0.05; the difference scores between pre-test and post-test follows a univariate normal distribution.

The paired-sample t test

By convention, in paired-sample t tests, the assumption is that H0: μ1 = μ2 (mu or mean of difference =0) and Ha: μ1 ≠ μ2. This means that the alpha is two-tailed (left-tailed, or right-tailed). The cut-off score becomes α/2=0.025. The paired-sample t test for the pairs pre-test and post-test yielded the following output:

RESULTS

Table 2 indicates that the p-values for all the six pairs is >0.025, which results in rejecting the H0 and accepting the Ha: mu ≠0. Except for the speed component that has a mean indicating that mean Speed pre-test > Speed Post-test (the mean difference is positive), other component suggest that the mix-training program was effective. But the speed component should be revisited for further intervention for those football referees. The statistical significance of the endurance and force physical test components are also pictorially highlighted below:

Table 2. Paired-samples t test output

Paired Samples Test									
		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Dev	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	SP_Pre-Post	.45	.17	.045	.35	.54	10.00	14	.000
Pair 2	END_Pre-Post	-4.92	1.19	.30	-5.58	-4.25	-15.97	14	.000
Pair 3	PUSH_Pre-Post	-7.60	4.43	1.14	-10.05	-5.14	-6.63	14	.000
Pair 4	LEGCU10KPre-Post	-32.06	13.23	3.41	-39.39	-24.73	-9.38	14	.000
Pair 5	LEGPRES45K Pre Post	-25.40	7.20	1.86	-29.39	-21.40	-13.64	14	.000
Pair 6	LECURLA3M10K Pre -Post	-90.93	46.00	11.87	-116.41	-65.45	-7.65	14	.000

Given the Figure 1 legend for the pre-test and post-test, all the pairs suggest improvement on the tested component, again except for speed even visually does not indicate much. The most significant is in pair 6, that is, the LEG CURL.A/3MIN (10KG). The post program shows much better improvement. Figure 1 also shows that Pair 4, that is, LEG CURL.C/MIN (10KG), suggests the referees' major improvement on it.

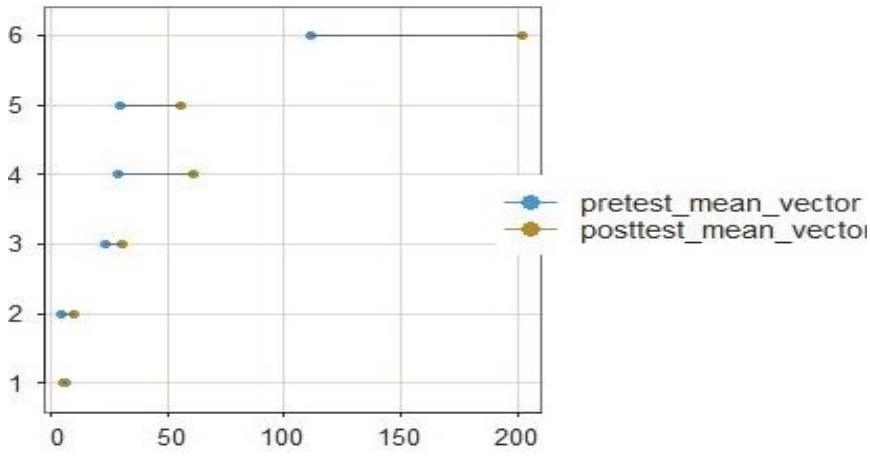

Figure 1. Pre-test and post-test mean vector plot

DISCUSSION

Under this section, the discussion is centered on answering the research questions. The first aspect to cover is the content validity of the program or intervention content and the reliability that physical test administered to foot match officiating professionals. Then there is the overall presentation of the effectiveness of the treatment given the pre-test and post-test scores. To begin, there is evidence of content validity of the mix-training treatment. The eight experts present during expert judgment focus group discussion, after their suggestions were included, they marked the training intervention component as "valid".

Validation of an intervention program in the sports domain is a practice that many researchers find cost effective and reliable. Sum, et al., (2016) got their "physical literacy instrument" validated through expert judgement through experts' panel. During that focus group discussion experts recommended improvements and when all is integrated as they suggested, they validated that instrument for physical education teachers.

Another intervention that got intervention components validated through expert judgement panel is reported in Kholis, et al., (2020), which echoes Van der Veken, et al., (2020). These authors too report community sports programs components that were validated through panels that hosted international experts in the domain required in those programs. Also used expert panel or focus group discussion to validate a tool on sport specialization.

As far reliability is concerned, the intraclass coefficient for the physical sets of tests is ICC= 0.77. This coefficient value is higher than the cutoff score of 0.70 reported in for reliability index. With the ICC of 0.77, there is an indication of the physical education test replicability, (Artero, Espana-Romero, V., Castro-Pinero, Ortega, Suni, Castillo-Garzon, and Ruiz; 2011; Koo & Li, 2016). The reliability of the mix-training program is rather close to Munivrana, et al., (2022) tool's reliability of Alpha=0.76. There is also evidence that the physical test scores satisfy the normality assumption. Given the Shapiro-Wilk normality test, which is accurate for paired-samples with n<30, indicates W = 0.8054, p-value = 0.066. The p-value is 0.066 >0.05 shows that the difference scores between pre-test and post-test follows a univariate normal distribution, (Rejeki, et al., 2023; Basrizal, 2024).

The discussion the aspects of the training validity and reliability brings answer to research question #1 about "How valid and reliable the mix-training program is" given the Burundian football referees' needs. The expert panel used to validate the program or intervention is accurate and the ICC=0.77 is an indicator that repeating the program under similar conditions on a sub-group of football match officiants would yield similar results. Equally, the normality assumption was verified and the p-value 0.066>0.05, indicating that the difference scores between pre-test and post-test follows a univariate normal distribution.

To draw conclusion on the overall effectiveness of the treatment or mix-training program, we analysis results of the paired-sample t test. For this intervention, pairs p-value is compared to the two-tailed (left-tailed, or right-tailed) conventional $\alpha/2=0.025$, (Rulismi, Sahil & Dali, 2024). All the six pairs are sig.<0.025, which allows us to reject the H_0 and accepting the H_a (mu $\neq 0$). Rather, there is improvement on the tested components.

Given the different Pre-test score mean-post-test score mean that is positive, this signifies insignificant threshold on the "Speed" component. Similarly, some components about decision-making training in football umpires were found statistically insignificant in Kittel, Elsworthy & Spittle (2019). In this training program for referees, only the speed component is controversial (Samarein, Samanipour, Asjodi, Shokati, Fallahi, Brownlee & Oliveira, 2023), others were statistically significant. Although referees need to move quickly to keep up with the play, especially during counterattacks or fast breaks, (Castagna, Bizzini, M., Póvoas, Schenk, Büsser & D'Ottavio, 2019), speed was not significantly improved probably due to parameters like age and body mass of the referees, which echoes.

The fact that all the sig. values are less than 0.025 (p-value<0.025) sheds light on the answer to the research question "What is the evidence proving the mix-training program effectiveness for Burundian football referees?" There is enough evidence that the mix-training program was effective give the difference between the pre-test and post-test scores.

Other research, with the intervention was mostly effective on the components LEG CURL.A/3MIN (10KG) and LEG CURL.C/MIN (10KG), which suggests the football referees' major improvement on these two as the post-test means are almost double of the pre-test scores. The overall effectiveness of this training program for football match officiants indicates that football referees need physical training of this kind, (Nathan, 2016; Kabadayı, Yılmaz & Bostancı, 2021).

To conclude, it should be noted that the mix-training program designed to enhance Primus League football referees' speed, endurance, and strength was successful. Validated by experts in the domain of Fitness and Vitality Enhancement (FVE), the intervention was not only found reliable, but its effectiveness was also verified. The football match officiating professionals' endurance and strength improved, which was evidenced by the statistical significance of related paired-samples t test. The speed component, although statistically significant has a mean that shows not difference between speed related pre-test and post test scores, which casts doubt on the effectiveness of this component of the intervention. Given such a conclusive remark, it is recommended that further research be carried out with wider samples and that there be established the relation between the referees' age, body mass, and speed.

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Conflict of Interest

We declare that the article we have written is not involved in any conflict of interest.

Ethics Statement

This research has met ethical rules. Research ethical approval was obtained Research Ethics Committee with project number 021/REC/2024.

Author Contributions

Study design: EB & JN; Data collection: JN & FB; Statistical analysis; EB, JN; Data interpretation; EB, JN & CCVL; Literature search; EB & JN. All authors have read and approved the published version of the manuscript.

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