International Journal of Human Movement and Sports Sciences 11(2): 326-334, 2023 http://www.hrpub.org
DOI: 10.13189/saj.2023.110209

Optimized Training of Force-Velocity Profiling on Young Sprinters' Performance: A Systematic Review

Teng Seet May[1,*], Asmadi Ishak[1], Mohd Azrul Anuar Zolkafi[1], Chin Ngien Siong[2]

[1]Sultan Idris Education University, Tanjung Malim, Perak, Malaysia
[2]Institute of Teacher Education Batu Lintang Campus, Kuching, Sarawak, Malaysia

Received December 15, 2022; Revised February 13, 2023; Accepted March 12, 2023

Cite This Paper in the Following Citation Styles

(a): *[1] SM. Teng, A. Ishak, MAA. Zolkafi, NS. Chin , "Optimized Training of Force-Velocity Profiling on Young Sprinters' Performance: A Systematic Review," International Journal of Human Movement and Sports Sciences, Vol. 11, No. 2, pp. 326 - 334, 2023. DOI: 10.13189/saj.2023.110209.*

***(b)*:** *SM. Teng, A. Ishak, MAA. Zolkafi, NS. Chin (2023). Optimized Training of Force-Velocity Profiling on Young Sprinters' Performance: A Systematic Review. International Journal of Human Movement and Sports Sciences, 11(2), 326 - 334. DOI: 10.13189/saj.2023.110209.*

Abstract Force-velocity imbalance (FVimb) has been proposed as an effective tool for pre-scribing training loads to improve physical performance. An optimized training program was used according to individual Fv-profile to decrease FVimb thus indirectly improving sprint performance. This systematic review aimed to study the effectiveness of optimized training based on force-velocity (Fv) profiling in sprint performances among young athletes. The database of Google Scholar, ProQuest, Scopus, and PubMed was conducted in March 2022, and studies published since 1990 were considered for inclusion. A total of 2873 publications were initially identified, of which 6 studies qualify for this review. The studies were independently evaluated for methodological quality and evidence of specific training effects on optimized training. Altogether there were 244 highly or semi-trained athletes (20±5 years,80± 13kg). This review suggests that optimized training based on Fv-profile was more efficient than the generalized training program as 70.1% of participants had improved their jump and sprint performances based on their Fv-profile by reducing their FVimb. However, there is still a limitation to the studies. Future work should focus on critical factors such as training duration, sample size, and immediate assessments to ensure a better performance regarding optimized training based on Fv-profile.

Keywords Individualized Training, Force-Velocity Profiling, Sprint Performance, Young Athlete

1. Introduction

Ballistic muscle contraction will determine performances according to the abilities of neuromuscular muscle to achieve the maximal velocity at the shortest duration with its body weight, especially when jumping or sprinting takes place [1]. Ballistic performances are not only influenced by maximal power (Pmax) output but are also highly influenced by the individual characteristic which is known as force-velocity profile. Hence the measurement of the Fv-profile provides an important medium to represent the athlete's maximal performance. This force-velocity profile led to more optimized and effective training interventions to overcome the athlete's weakness. The difference between the actual and optimal Fv-profile symbolizes the magnitude and the direction of the unfavorable equilibrium.

Quantifying Force-velocity imbalance (FVimb) on individual weakness could help improve the efficacy of training programs by adapting to individual needs [2]. In theory, this will lead to a decrease of FVimb toward an optimal value and will induce a greater increase in maximal power (Pmax).

The general training method had been considered to have power improvement for ballistic training, but this type of training that is suited for all programs had resulted in contrast in jumping performance maybe because of different characteristics of the athletes. Instead of improving the Pmax but had indirectly increased the Fvimb which could lead to a decrease in the ballistic performance.

Hence the purpose of this systematic review is to look into the efficacy of optimized training based on force-velocity (Fv) profiling in sprint performances among young athletes.

2. Methods

Search Strategies

The study focused on the search in online databases which consisted of Google Scholar, ProQuest, Scopus, and PubMed. The procedure of searching was the same in each of the databases. The title, abstract and full text were screened for the relevant studies. The researcher only searched for publications in English and did not limit the year of the finding to avoid any of the miss out on information. The following keywords in term or group were connected with an "AND".

1. Individualize training
2. Force-velocity profiling
3. Sprint performances
4. Young athlete

Furthermore, the current literature was cross-referenced.

3. Inclusion and Exclusion Criteria

Articles were chosen for inclusion if they were written in English and full texts were available. The researcher only chose original articles with human beings as participants. The participants were required to have a strength-training background ranging from a minimum of 1 year and required to a minimum of average (12 hours in the weekly training) and were well-known with the testing procedure. The training intervention consisted of three separate sessions and included studies with either quasi or experimental design with at least one pre and post-test.

Articles will not be taken if the subject were referees, coaches, injured or special population athletes such as veteran because this research only focus on young athletes The researcher used a three-phase PRISMA statement proposed by [3] to search thoroughly for relevant articles. At first, the researcher had a literature identification in the 1st phase. Then the selected articles were recorded and screened in the 2nd phase. Articles were also evaluated by abstract and full text for eligibility in this phase and finally included the related articles which had to meet the criteria in the 3rd phase. Eventually, with the use of the PRISMA method, a total of 6 articles were highlighted and were eligible for further evaluation.

4. Examination of Methodological Quality

The intervention training guideline was based on specific FVimb thresholds as mentioned by [1]. In their guidelines, they outlined six loading focuses or targets with 3 to 5 exercises per loading focus, and with a specific percentage of training load.

In this systematic review, all 6 selective articles had been independently scaled based on these 7 main characteristics. The first characteristic was according to the group design and was scaled according to the number of intervention groups. One intervention group was given 1 point, two intervention groups were given 2 points and more than 3 intervention groups were given the maximum score of 3.

The second characteristic was scaled for the sample size. The sampling size per group was given with 1 point if N< 6, 2 points were given if N> 6-11, and 3 points were given for N>11 or above. The third characteristic was scaled based on the outcome of their performances in the experiment. When the outcome was measured less than half was evaluated with 1 point. When the outcome measured improved by more than half after the intervention was given by 2 points.

The fourth characteristic was scaled for the test-retest effects with at least one pre-test and one post-test. Experiments conducted with multiple pre-tests before the intervention or at least one retention test after the post-test were given 1 point. Experiments that had measurement in the middle of the intervention before the post-test was given with 2 points. The fifth characteristic that had been rated was for the sampling group. The selected articles' experiment used purposive sampling. Normally, intervention studies always have a small sample size for easy management of the sample and to ensure the effectiveness of the intervention. The quasi-experimental group was given 1 point and 2 points were given to the experimental group.

The next characteristic was scaled for the statistic method. 0 point was given if there were obvious errors and 2 points were given for appropriate analyses. The last characteristic to be scaled was for the intervention. 1 point was given if each session lasted a minimum of eight minutes, 2 points were given for subjects who train at least twice per week, and 3 points for subjects who had trained at least 4 times per week.

Based on the item scores in each characteristic (Table 1), a final mark had been calculated for assessing the methodological quality.

5. Result

First, a sum of 2873 papers was pinned down from the search with the keywords (1st phase, identification). The search had been accomplished in (Google Scholar, 2820 papers), ProQuest-25 papers, Scopus-2 papers, and Pubmed-26 papers. Then, we cut out 2827 papers by the duplicate record before the screening phase (2nd phase)

The balance of 46 papers was checked again for inclusion and exclusion criteria in the screening phase and analyzed individually by abstract. A sum of 40 papers did not fulfill the criteria and was cut out after detailed evaluation such as no athlete or experience in interactive sport, no intervention, and no original data. Finally, only 6 papers were selected for the (3rd phase, included). Figure 1 gives an outline of the study identification and selection.

Overall, the standard scores ranged from 13-16 with a total score of 17 points. The mean standard score was M=14.17 (SD = 3.76). Table 1 gives a general outlook of the methodology quality of the included studies.

The outcome was used to represent the summary of the effectiveness of the optimized training based on the force-velocity profile (Table 1).

The result of the intervention was shown in Table 2. Out of 6 studies, only 4 studies showed strong evidence of optimized training performances based on force-velocity profile. Whereas, 2 studies showed weak evidence on performance due to certain limitations in the studies.

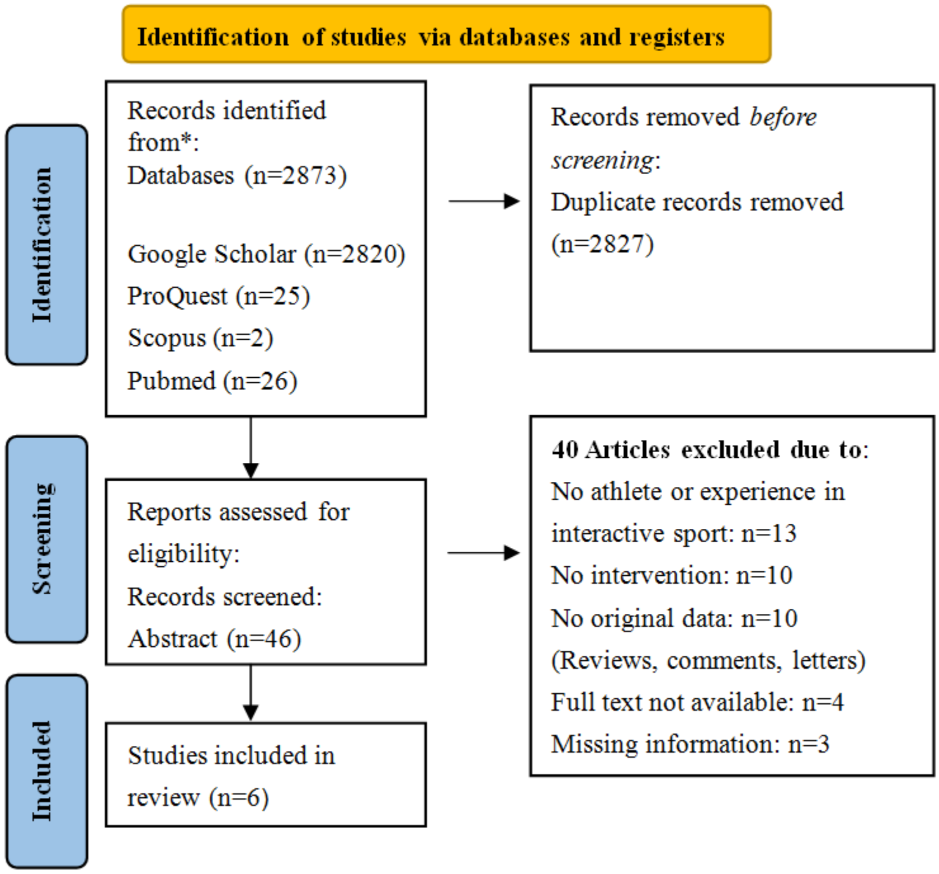

Figure 1. Study selection flow chart based on the PRISMA statement

Table 1. Included studies rated by methodological quality in seven items

Researcher name	Design	Sample size	Outcome	Test-retest	Sampling Group	Statistics	Intervention	Score max 17
(Jiménez-Reyes et al., 2017)	3	2	2	1	2	2	2	14
(Lindberg et al., 2021)	3	2	1	1	2	2	2	13
(Jiménez-Reyes et al., 2019)	3	3	2	2	2	2	2	16
**(Jiménez-Reyes, et al., 2016)	3	3	2	1	2	2	2	15
(Zabaloy et al., 2020)	3	2	2	2	2	2	2	15
(Rakovic et al., 2018)	2	2	1	1	2	2	2	12

** Not full text but chosen due to providing all the information needed. Hence equal to the full text.

Table 2. Overview of included studies

Authors	Objective	Sample	Design & Sampling group	Measurement performance	Test-retest	Analysis	Intervention	Time period	Result
Jiménez-Reyes et al., 2017)	To test individualized training program based on the individual F-v profile would decrease subjects' individual FV imb and in turn, improve vertical jump performance.	84 trained athletes. Age (23 ± 4.4 year) Weight (75.5 ± 8.5 kg)	3 intervention group (Experimental) FD-22 VD-18 WB-6	46/46 intervention group	Pre-post test	A repeated measure ANOVA, Standardized ES	2x per week	9 weeks	1. Force deficit sub-group-moderate to a large increase in Fo, FV imb reduction in all subjects 2. Velocity Deficit sub-group-moderate to an extremely large increase in Vo. Improving velocity quality 3. Well-Balence subgroup- moderate increase in Fo. Moderate jump height improvement and a small increase in Pmax. 4. Performance improvement can only be attributed to FV-imb reduction, and not to an increase in Pmax. (Only mixed resistance training load to increase maximal power output,
(Lindberg et al., 2021)	To examine the effectiveness of an individualized training program based on force-velocity (FV) profiling on jumping, sprinting, strength, and power in athletes	40 national-level team sport athletes. Age (20 ± 4 year) Weight (83 ±13 kg) from ice hockey. Handball, and soccer	3 intervention group(Experimental) VD-5 FD-20 WB-15	11/60 intervention group	Pre-post test	Samozino method, ANCOVA, t-test, correlation coefficient	2x per week	10 weeks	1. 5 participations (velocity deficit), 20 (force deficit), and 15(well balanced) - no significant difference in FV imb reduction. 2. SJ-FV PARAMETER-no significant different 3. Change in Sj-power is significantly related to SJ-HEIGHT and CMJ-height but unrelated to 10m, and 30m sprint. 4. SJ-FV Profiles were negatively correlated with the changes in SJ height. 5. Heavy strength participants--increase leg press Fo and Pmax. 6. High-velocity prog did not increase Vo. 7. Well-balanced prog----increase Pmax but not Fo and Vo.

Table 2. Continued

(Jiménez-Reyes et al., 2019)	1. Analyze the changes in the fv power variable and jump performance response to individualized training program based on fv imb. 2. The individual adaptation kinetic to reach the optimal profile. 3. De-training kinetic over 3 weeks following.	60 semi-pro or profesional soccer or rugby player. Age (23.7±3.7 years) weight (76.4±9.3kg)	4 intervention group (Experimental) FD-18 High VD-10 Low FD-18 Low VD-14	60/60 intervention group	Pre-mid-post test	Standardized effect size, multiple regression analysis	2x per week	Not stated until athlete reach fv imb close to 0	1. The FD and VD groups showed extremely large changes in Fvimb in Fo. 2. Jump performance improvements were observed in the FD and VD groups.
(Jiménez-Reyes, et al., 2016)	Determine the effects of an individual specific force-velocity profiling-based training	63 highly trained player	3 intervention group (Experimental) FD-11 VD-8 WB-44	19/63 intervention group	Pre-post test	1 way ANOVA	2x per week	9 weeks	A greater increase in jump performances with a decrease in FVimb compares to the control group.
(Zabaloy et al., 2020)	Aimed to analyze the effects on lower body strength, jump and sprint performance of different individualised resistance training (RT) programs based on Fvimb in rugby players	34 highly trained rugby players	3 intervention group (Experimental) VD-6 FD-11 WB-9 NI-8	26/26 intervention group	Pre-Mid-post test	shapiro –wilk 2 factorial Anova	2x per week	7 weeks	The Vimb group significantly ($P < 0.05$) increased V0, whereas decreased F0 and Fvimb. The Fimb group showed significant ($P < 0.05$) decreases in V0, whereas increased F0 and Fvimb. The WB and Nl groups did not show significant changes in these parameters. The WB group induced significant enhancements in 10 m, 20 m, and 30 m sprint times, maximum sprint speed and sprint momentum (SM), whereas Fimb attained significant changes in 20 m and 30 m sprint times. The NI group attained significant improvements ($P < 0.05$) in SM. No significant changes were observed for 1RM-SQ and jump performance.

Table 2. Continued

(Rakovic et al., 2018)	Evaluate whether an individualized sprint-training program was more effective in improving sprint performance in elite team-sport players compared to a generalized sprint-training program.	21 female handball player. Age (23 ± 3 years) Weight (73 ±6 kg)	2 intervention group(Experimental) Resisted Sprinting-3 Asisted Sprinting-4 MIX-4 (4 Drop out during intervention)	9/9 intervention group	Pre-post test	Shapiro-Wilk Test	2x per week	8 weeks	1. Both groups improved their 30-m sprint performance by 0.05–0.06 s on average (~1%; small effect). 2. Both groups improved V0 by ~2% (moderate effect). 3. Both groups display larger improvement for maximal velocity sprinting than for acceleration sprint performance. 4. Ineffective sprinting- too much upper body raise during initial acceleration influences the mechanical outputs.

Abbreviation: SJ, Squat Jump; CMJ, Countermovement Jump; FD, Force- Deficit; WB, Well-Balanced;VD, Velocity Deficient; FV-imb, Force-velocity Imbalance; NI, Not individual; RT, Resistant Training; Fv-profile, Force-velocity Profile.

6. Discussion

The purpose of this systematic review was to assess the potential of the optimized training based on force-velocity profile on pre-post training intervention and aimed at improving performance either in ballistic performances or reducing FVimb of the athletes. All of the articles had performed at least 7 weeks of separate training sessions to study the intervention outcome. This systematic review helps to provide a general outlook of the methodological quality and the included intervention studies

6.1. Methodology

Overall, 6 studies met the above-specified criteria. None of the selected studies reaches the maximum score of 17 points which has a sufficient number of interventions and participants involved in the studies. A mean score of (M= 14.17) showed methodological improvement. 5 out of 6 studies had been carried out by using more than 1 intervention group, attesting that the use of active comparison of controls group to compare the effects of intervention in sports training.

Whereas, only 2 out of 6 studies had reached the maximum score of 3, with more than 11 participants per group. Most of the studies involve between 5 to 10 participants in a group. This will increase the risk of underpowering and sampling errors [1,4] on power failure in neuroscience studies.

Group tasks play the important role in the interpretation of the effects. It is important to have an intervention in the experimental research on the effects of the placebo and the control groups. Placebo and control groups may lead to different pre-test scores besides another discriminating characteristic that will lead to different improvements. The finding showed that the methodological empirical base on optimized training still required an improvement to reach significant performance. Nevertheless, intervention control that uses elite athletes to gain an ineffective to induce performance changes is considered to be unethical.

6.2. Methodology Consideration When Implementing Optimize Training and Future Research Directions

A study revealed that it was tough to evaluate the publication bias effects in the context, roughly 70.1% of the finding recommend that optimized training leads to a specific task had increased performance. The remaining 29.9% of cases had shown no effects because of the intervention. The results might be due to improper training loads or training equipment. However, it is true for positive effects due to the sampling errors. Only 4 out of 6 studies showed strongly integrated evidence for positive performance

Several research groups have suggested that implementing an optimal force-velocity profile may allow for better performance [1,2,4,5]. It also has been suggested that force-velocity imbalance can serve as a valid indicator of the player’s weakness [1,2]. While this presents a considerable advancement for optimal performance. There are a few methodological factors that could compromise the utility of the research and practice. First, its intervention has not clearly stated the difference in the volume taken during the intervention. Most of the past researchers had used different loading but the same volume of training, but we know that different loads but the same volume will not have a significant performance as the volume has reached a minimum threshold [10]. That is the reason why most of the Pmax in the past research did not increase but was only able to reduce FV-imb.

Second, researchers have recommended using a longer period of time to access the intervention training to provide a better performance from the sample [3]. The argument is strengthened by the fact that the number of training duration performed is not significant with a fixed duration training [1,2,4,5,6]. The training intervention should have been sufficient for each individual to reach FVimb close to 0. A 7-week, 8-week, or 9-week duration was close enough to the Velocity deficit individual but not for the Force Deficit individual.

The larger the initial deficit, the longer the training duration to reach an optimal profile. The training duration needed for high-deficit players requires them to have at least (4-25 weeks of training) to reach the optimal FV-imb [1]. Collectively, based on the studies included in the present overview, it seems that the use of training duration could result in a considerable variety of the actual number of weeks needed to reach optimal performance. Whether this variable could affect the result of the sample performance presents an interesting avenue for future research.

Third, past researchers should have taken action against the one who had less attendance in the training program [2]. The number of training sessions is important and the efficiency of the training session will influence the performance in the post-test. Participants which had less than 80% should have been expelled from the study which can influence the data and the result of the performance. This limitation should be considered in practice and future research should investigate ways of reducing this variability.

Fourth, assessment during the intervention. From what we had observed from the past researchers, most of the interventions were only taken pre and post-test [1,2,6]. The researcher should have taken an intermediate assessment. This is because intermediate assessment would easily allow to finely tune the training program and adapt it to the kinetics of the individual. Therefore, future research should be considered in practice to make the result more precise.

Fifth, past researchers had not clearly explained the procedure of any velocity tracking throughout the intervention studies [1,2,3,4,5,6]. If required to use the percentage of 1RM training load in Resistant Training, daily velocity tracking is needed for each session of training. This is because loading prescription based on 1RM is less accurate and may fluctuate daily due to fatigue and training adaptation. Therefore, future research should consider using velocity-based training to eliminate this limitation and to track daily 1RM before conducting any of the intervention programs.

Last but not least, an unbalanced or insufficient sample size eventually influences the data [1,2]. As mentioned in the previous research, this uneven allocation between subgroups can lead to smaller statistical power compared to what was calculated in one group. Therefore, it is important to ensure that the sampling size has enough or more than 11 sampling per group so that the result of any experiment can be significant [2,5,6]. Considering this and the conflicting results already reported in the literature, future studies should be conducted to address the potential utility to optimize the training.

7. Limitation

Several aspects of this review should be considered when interpreting the findings. First, there were considerably fewer female participants in the optimal training which reduces the generalizability of our findings to female participants. More research on optimal training should include female individuals when possible. This is because male and female individuals might be responding similarly to different fv thresholds; although, more research is needed to substantiate these claims. Second, a few researchers used elite athletes in their research. This is because the elite normally attaches to their own national training. Hence their attendance at the intervention training will be low. Researchers suggest not taking the elite as a sampling subject. Third, there is research considering the kinetic of detraining over a 3-week period. 3 weeks is common for a taper period usually performed in team sports. However, it is not possible to have a prolonged detraining period during the in-season. Last, past researcher took their intervention studies during the in-season period. It is recommended not to take the intervention program during in season because it will affect their sprinting and jump performance due to neuromuscular fatigue that is accumulating throughout the season.

8. Conclusions

Based on the selected articles, it can conclude that an optimized sprint training intervention based on a force-velocity profile was found to be more effective than a generalized sprint training intervention in enhancing accelerated and maximal velocity sprinting performance. Reducing the actual force-velocity imbalance can reduce athlete weakness and thus improve the athlete's performance. However, there is still imperfection in the studies. A lot of methodological approaches need to be considered such as the sampling size, the duration of the intervention, training session, having at least a placebo to control the expectancy effects or a balanced group sampling should be thoroughly considered. Moreover, several other factors need to take into consideration in future studies such as immediate assessment, volume load, sprint-specific mechanical output, and sprint training at all seasons. A more focused systematic review can have a high impact on providing a more in-depth examination of optimized training based on the force-velocity profile. Thus, it will help verify the effectiveness of the intervention of optimized training in the field of modern sports science.

Declarations

Funding

This research received no external funding.

Conflict of interest

All authors declare no conflict of interest in this review.

Informed Consent Statement

Not applicable.

Ethics Approval

Not applicable.

REFERENCES

[1] P. Jiménez-Reyes, P. Samozino, JB. Morin. Optimized training for jumping performance using the force-velocity imbalance: Individual adaptation kinetics. Plos One 14(5): e0216681, 2019.

[2] P. Jiménez-Reyes, P. Samozino, M. Brughelli, JB.Morin. Effectiveness of an individualized training based on force-velocity profiling during jumping. Front Physiol 7: 677-690, 2017.

[3] B. Kitchenham, O. Pearl Brereton, D. Budgen, M. Turner, J. Bailey, S. Linkman. Systematic literature reviews in software engineering - A systematic literature review. Inf Softw Technol 51(1): 7–15, 2009.

[4] KS. Button, JPA.Ioannidis, C. Mokrysz, BA. Nosek, J. Flint, ESJ. Robinson, MR. Munafò. Power failure: Why small sample size undermines the reliability of neuroscience. Nat Rev Neurosci 14(5): 365–376, 2013.

[5] K. Lindberg, P. Solberg, BR. Rønnestad, MT. Frank, T. Larsen, G. Abusdal, S. Berntsen, G. Paulsen, O. Sveen, O. Seynnes, T. Bjørnsen. Should we optimized training based

on force-velocity profiling to improve physical performance in athletes? J Med Sci Sports 31(12): 2198-2210, 2021.

[6] E. Rakovic, G. Paulsen, C. Helland, O. Eriksrud, T. Haugen. The effect of individualized sprint training in elite female team sport athletes: A pilot study. J Sports Sci 36(24): 2802-2808, 2018.

[7] S. Zabaloy, F. Pareja-Blanco, JC. Giráldez, JI. Rasmussen, JG. González. Effects of individualised training programmes based on the force-velocity imbalance on physical performance in rugby players. Isokinet Exerc Sci 28(2): 181-190, 2020.

[8] DM. Frost, JB. Cronin, RU. Newton. Have we underestimated the kinematic and kinetic benefits of non-ballistic motion? Sports Biomech 7(3), 372–385, 2008.

[9] B. Requena, I. García, F. Requena, E. De Villarreal, S.S, J.B. Cronin. Relationship between traditional and ballistic squat exercise with vertical jumping and maximal sprinting. J Strength Cond Res 25(8), 2193–2204, 2011.

[10] KJ. Ostrowski, GJ. Wilson, W. Robert, PW. Murphy, AD. Lyrrle. The Effect of Weight Training Volume on Hormonal Output and Muscular Size and Function. J Strength Cond Res 11(1), 148–154, 1997.