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Integrative Effects of Vinyasa Yoga and Animal Flow Exercises on Sprint Performance and Physiological Adaptations in Adolescent Male Sprinters

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Abstract

Objectives. The aim of the study was to investigate whether the implementation of Vinyasa yoga or Animal Flow exercises alongside a structured sprint training programme would result in greater improvements in selected performance and physiological variables among adolescent male sprinters compared with a control group that performed sprint training only.

Materials and Methods. Forty-five high-school male sprinters (16.0 ± 0.8 years) were randomly assigned to one of three conditions in a 12-week randomized intervention: sprint training only (ST), Vinyasa Yoga plus sprint training (VY+ST), or Animal Flow plus sprint training (AF+ST). All groups completed the same sprint training programme three times per week, while the experimental groups additionally performed 45 minutes of adjunct training on alternate days. Performance variables included 30-m sprint time, vertical jump height, and agility, whereas physiological variables included flexibility, estimated aerobic capacity (Cooper 12-minute run test), and resting heart rate. Pre- and post-test data were analysed using paired-samples t-tests and one-way ANOVA on change scores, with effect sizes reported.

Results. Both integrative training groups demonstrated significantly greater improvements across all performance and physiological variables compared with the ST group ($p < .05$). The VY+ST group exhibited comparatively larger improvements in flexibility, estimated aerobic capacity, and resting heart rate, whereas the AF+ST group showed greater gains in vertical jump performance and agility. Large between-group effect sizes were observed for all outcome measures.

Conclusions. The findings suggest that supplementing sprint training with Vinyasa Yoga or Animal Flow is associated with favourable and modality-specific adaptations in adolescent male sprinters. These integrative, movement-based approaches may serve as complementary strategies within youth sprint training programmes. However, given the indirect assessment of aerobic capacity and the absence of maturation control and a priori power analysis, the results should be interpreted with caution.

Keywords: Vinyasa yoga, Animal Flow, sprint performance, integrative training, adolescent athletes, physical fitness.

Introduction

Sprint performance is a multidimensional sport-related skill that is dependent on the interplay of neuromuscular force generation, biomechanical efficiency, intermuscular coordination, and metabolic support systems (Paradisis et al., 2019; Yoshimoto et al., 2019). The importance of sprint development is particularly attributed to performance in the track and field in adolescent athletes because sprinting is used to form the basis of performance in most school and academy level sports. In traditional sprint training programmes, priorities are commonly based on specificity, overload, and technical perfection, and put more emphasis on acceleration mechanisms, maximal velocity training, and strength power attributes attained with repeated sprinting, plyometrics, and resistance exercises (Derakhti et al., 2021). Although such methods are effective, the recent biomechanical and training studies indicate that neuromechanical and coordination-relevant factors, instead of force production, can often be the limiting factor of the sprint performance improvement (Okudaira et al., 2021; Hicks et al., 2023).

As new studies show, the sprint performance of a person is being conditioned by the quality of movements, the mobility of the joints, the stability of the trunk, and the efficiency of the coordination of multi-segmental movements at high running speeds (Edouard et al., 2022). In adolescence, increased growth and neuromuscular maturity would result in the realization of the further necessity of training strategies to enhance mobility, tissue tolerance, and neuromotor control in combination with conventional sprint-specific loading (Long et al., 2024). As a result, compliance with complementary training modalities that would improve flexibility, postural control, and coordination and generate a minimal increase in mechanical load or risk of injury interest is growing. Yoga borrowed with other mind-body forms including Vinyasa Yoga have focused on mind-body movement practices in athletic conditioning settings with a focus on controlled movement competence, breathing control and movement patterns. Previous investigations have reported that yoga-based interventions may improve flexibility, balance, and selected cardiorespiratory parameters in athletic and physically active populations (Chaouachi et al., 2008; Polsgrove et al., 2019; Raj et al., 2021).

Systematic reviews and meta-analyses further suggest small to moderate benefits of yoga and mindfulness-based interventions on physical performance outcomes, although the methodological quality of existing studies is variable and population-specific evidence remains limited (Saraswati et al., 2023; Gupta & Dhawan, 2022). Importantly, most yoga-related sport studies have focused on psychological outcomes or general fitness markers rather than sprint-specific performance indicators. In parallel, functional flow-based movement systems such as Animal Flow have emerged as novel conditioning approaches characterised by ground-based, quadrupedal locomotion, multi-planar transitions, and body-weight control. These movement patterns place high demands on trunk stability, shoulder–hip dissociation, proprioceptive control, and intermuscular coordination (Buxton et al., 2020).

The empirical research investigating the effectiveness of quadrupedal movement training has found that it leads to the improvement of the quality of functional movements, joint range of motion, and dynamic balance during the short to moderate-term period (Kullman et al., 2020; Buxton et al., 2022). Subsequent works conducted energy-expenditure, which provide proof of the moderate metabolic activity of novice-level Animal Flow sessions, hint at possible conditioning effects with minimum physiological stress (Buxton et al., 2022). Nevertheless, there are few pieces of direct evidence that can be used to connect Animal Flow-based training with sprint-specific performance results. In theory, the inclusion of a mobility oriented and coordination-oriented adjuncts in the sprint training programmes can play a role, with regards to performance, in more than one way. Reduced braking forces and increased stride length in the process of sprinting, and better force transmission in acceleration and change-of-direction exercises because of enhanced trunk stability and intermuscular coupling might be enabled by enhanced joint mobility and flexibility (Ding et al., 2023; Boynton et al., 2023). Also, practices about breathing movement that regulate movements can affect autonomic balance and recovery, which could facilitate repeated bouts of very, very strenuous sprinting (Brown & Gerbarg, 2005). In spite of these conceivable mechanisms, empirical data involving the concomitant effects of sprint training on yoga-founded or quadrupedal movement-founded programs in adolescent athletes are nonetheless but few. The recent sprint training literature highlights the need to implement multimodal training regimens, especially in young populations, to overcome coordination limits and efficiency of movement in addition to the normal speed development (Haugen et al., 2019; Skoglund et al., 2023). However, most existing studies have examined resistance- or plyometric-based adjuncts, with minimal attention given to integrative movement practices that prioritise flow, mobility, and neuromotor control. Consequently, there is a clear gap in the literature regarding the potential role of Vinyasa Yoga and Animal Flow as supplementary modalities within structured sprint training programmes for adolescent athletes.

Therefore, the purpose of the present study was to examine the effects of integrating Vinyasa Yoga or Animal Flow exercises with a standard sprint training programme on selected sprint-related performance and physiological variables in adolescent male sprinters. Specifically, changes in 30-m sprint performance, vertical jump height, agility, flexibility, estimated aerobic capacity, and resting heart rate were evaluated following a 12-week intervention. It was hypothesised that both integrative training approaches would be associated with greater improvements in performance and physiological outcomes compared with sprint training alone. Additionally, it was expected that Vinyasa Yoga would be more strongly associated with improvements in flexibility and estimated aerobic capacity, whereas Animal Flow would be more strongly associated with gains in explosive power and agility.

Materials and Methods

Research Design

The present investigation employed a 12-week randomized controlled experimental design with three parallel groups to examine the effects of integrative movement-based adjuncts combined with sprint training on selected performance and physiological variables in adolescent male sprinters. A pre-test–post-test structure was adopted to permit both within-group and between-group comparisons. Participants were randomly allocated to one of three groups: (a) sprint training only (ST), (b) Vinyasa Yoga combined with sprint training (VY+ST), or (c) Animal Flow combined with sprint training (AF+ST). Random allocation was used to reduce selection bias, and all training sessions were conducted under supervised, standardized conditions.

Participants

The study involved forty-five healthy male high-school sprinters (mean age = 16.0 ± 0.8 years) who were involved at will. All the participants were at least one year experienced with systematic sprint-training, and were currently participating in school-run sprint competitions at recruitment. People were not allowed to participate in the study in case they had musculoskeletal injury, neurological disorder, or medical condition that could impair high-intensity training.

The participants were randomly divided into three (equal) groups of participants (n = 15 per group) ST, VY +ST, and AF +ST. The provisions of attendance at the training were followed through the intervention period and only individuals who attended at least 90% of the entire scheduled training were included in the final analysis. Age was not formally measured (e.g. peak height velocity) because the sample was adolescent. This element has been noted to be a limitation when interpreting training-related adaptations. Parental and participant consents were taken before their enrolment. Procedures employed were all ethically acceptable according to the institutional standards.

Training Protocols

Everyone underwent the same sprint training programme through the 12 weeks intervention period. The dynamic warm-up activities, repeated short-distance sprints (30-60 m), acceleration drills and sprint-specific-plyometric exercises were made up of the programme, which was held thrice in a week on alternate days. The intensity of sprints was between about 85 percent and 95 percent of maximal effort and the work to rest ratio was about 1:6. The sprints took about 60 minutes, which comprised the warm-up and cool-down periods.

The VY+ST and AF+ST couples had an extra 45 minutes adjunct training periods on alternative days, not in conjunction with sprint sessions. Dynamic yoga postures, asanas centered on movement, and sequences of movement with rhythmic breathing were the main focus of the Vinyasa yoga programme aimed at trunk stability, movement control and flexibility. Animal Flow programme involved organized, ground-based quadrupedal locomotor formats, multi-planar transitions, and flow sequences that were aimed at challenging coordination, core sales, and neuromotor management. Each child was under the guidance of an instructor who was qualified and had relative certification in sprint training, yoga or Animal Flow. Groups were standardized on training volumes and progression with gradually increasing intricacies and time over the intervention period. A summary of training protocols can be seen in Table 1.

Outcome Measures

The performance-related and physiological variables were evaluated by the measurement one week prior to (pre-test) the 12-week training intervention and at the time of (post-test) the intervention. The entire testing was done on the same environmental conditions (temperature: 25 ± 2 C; time of day: 08:00-10:00 h) in order to reduce the effects of diurnal and environmental variations.

Performance Variables

Sprint Performance: Sprint speed was measured by a 30-m sprint test that was done starting off. They were electronic timing gates with an error of within 0.01 s. All subjects went through a series of 3 maximum-effort trials, and the best time will be used to analyze them.

Vertical Jump Height: Lower-body explosive power was measured a countermovement vertical jump test that was measured by a Vertec device. Those involved were asked to swing the arm three times, and the maximum height of jumping (cm) was noted.

Table 1. Overview of 12-Week Training Protocols for Each Experimental Group

Component	Control (ST)	Vinyasa Yoga + Sprint (VY + ST)	Animal Flow + Sprint (AF + ST)
Duration	12 weeks	12 weeks	12 weeks
Frequency	3 sessions · wk^{-1} (alternate days)	3 sessions · wk^{-1} (alternate days)	3 sessions · wk^{-1} (alternate days)
Session Length	60 min (10 min warm-up + 40 min sprints + 10 min cool-down)	Same sprint session + 45 min Vinyasa Yoga on alternate days	Same sprint session + 45 min Animal Flow on alternate days
Sprint Content	Dynamic warm-up; 30–60 m repeated sprints; acceleration drills; plyometric bounding; work: rest 1:6; intensity 85–95 % max	Identical sprint content	Identical sprint content
Supplement Focus	-	Dynamic asanas emphasizing flexibility, breathing control, and mobility	Multi-planar, ground-based locomotion emphasizing stability and coordination
Representative Exercises	-	Surya Namaskar A/B, Warrior I–III, Plank → Chaturanga, Downward Dog, Tree Pose	Ape, Beast, Crab, Scorpion, Side Kick-Through, switches and flows
Supervision	Sprint coach	Certified yoga instructor + sprint coach	Certified Animal Flow instructor + sprint coach
Progression	Gradual increase in sprint intensity and volume	Extension of flow duration and pose complexity	Integration of longer continuous flows and advanced transitions
Recovery Strategy	Passive rest between sprints (1:6 ratio)	Yoga-based breathing and static stretching	Controlled mobility and breathing sequences

ST = Sprint Training; VY + ST = Vinyasa Yoga + Sprint Training; AF + ST = Animal Flow + Sprint Training. All the groups undertook 36 sessions within 12 weeks.

Agility: Agility was assessed by ensuring that the respondents underwent the Illinois Agility Test whereby participants were tested to walk very fast in many different directions around the same cones that had been standardized. Timing gates were electronic, and the trial time was faster than this, so it was analyzed. The investigators conducted all performance tests in the same manner with standardized procedures to make the results consistent and reliable.

Physiological Variables

Flexibility: Flexibility in the case of the assessment was measured by the sit-and-reach test that was conducted on a standard sit-and-reach box. Three trials were done and the farthest distance travelled (cm) was noted.

Aerobic Capacity: It was determined indirectly by using the Cooper 12-minute run test. The total distance travelled was worked out to be in estimated maximal oxygen uptake (VO_2max, $ml{\cdot}kg^{-1}{\cdot}min^{-1}$) based on the developed regression equation. Since this is a field-based estimation, the results are perceived as estimated aerobic capacity and not the direct VO_2max.

Resting Heart Rate: Resting heart rate was the measure of heart rate in a seated position after five minutes of silent rest with the use of a validated heart-rate monitor. The minimum stable beat per minute value was entered.

Statistical Analysis

IBM SPSS statistics (version 26.0) were used to analyse data. The descriptive statistics are given in the form of the mean ± standard deviation. The Shapiro-wilk test and Levene test were used to check data normality and homogeneity of variance respectively. Paired-sample t-tests were applied to compare within-group pre and post scores, whereas the paired-sample t-tests could not determine the differences between groups, and one-way (ANOVA) analysis of variance was done on the change scores. In case of large F-values, Tukey HSD post-hoc tests were used in order to determine pairwise differences. The statistical test was determined to be $p < .05$. To be able to interpret the practical relevance, effect sizes were computed. Within-group effects were analysed with Cohen d (small = 0.20, medium = 0.50, large = 0.80), and ANOVA effects (small = 0.01, moderate = 0.06, large = 0.14) to assess the effects, based on the existing methodological recommendations. Pragmatic factors included in an a priori power analysis were not performed before the recruitment of participants because of school-based availability of athletes. Therefore, there must be more caution in regards to the interpretation of effect size estimates and the findings can be considered exploratory whether it is in regard to the study design.

Results

The findings of the 12-week intervention are displayed in performance-related and physiological variables in the three groups. Table 2 presents descriptive statistics (mean ± standard deviation) of pre-test and post-test measures, whereas the change that exists within groups is summarised in Table 3, and the difference that occurs between groups is summarised in Table 4. The initial performance level and physiological condition of the groups were similar in terms of the baseline values as all the variables were similar in baseline value. All statistical analyses were conducted according to the procedures outlined in the Methods section, and findings are reported without interpretative inference.

Table 2. (Mean ± SD) for Performance and Physiological Variables at Pre- and Post-Test (N = 45)

Variable	Group	Pre-test (M ± SD)	Post-test (M ± SD)	% Change
30 m Sprint (s)	ST	5.14 ± 0.24	5.08 ± 0.21	1.2 ↓
	VY + ST	5.13 ± 0.26	4.82 ± 0.22	6.0 ↓
	AF + ST	5.12 ± 0.23	4.79 ± 0.20	6.5 ↓
Vertical Jump (cm)	ST	37.2 ± 2.8	38.1 ± 3.0	2.4 ↑
	VY + ST	37.5 ± 2.7	41.8 ± 2.9	11.5 ↑
	AF + ST	37.6 ± 2.6	43.0 ± 2.7	14.4 ↑
Agility (s)	ST	18.41 ± 0.63	18.32 ± 0.60	0.5 ↓
	VY + ST	18.35 ± 0.59	17.72 ± 0.53	3.4 ↓
	AF + ST	18.33 ± 0.57	17.46 ± 0.51	4.7 ↓
Flexibility (cm)	ST	23.4 ± 3.1	24.0 ± 3.0	2.5 ↑
	VY + ST	23.3 ± 3.2	28.5 ± 3.4	22.3 ↑
	AF + ST	23.5 ± 3.1	27.2 ± 3.3	15.7 ↑
VO_2max ($ml{\cdot}kg^{-1}{\cdot}min^{-1}$)	ST	41.2 ± 3.4	41.9 ± 3.6	1.7 ↑
	VY + ST	41.3 ± 3.5	46.1 ± 3.8	11.6 ↑
	AF + ST	41.5 ± 3.3	45.2 ± 3.6	8.9 ↑
Resting HR (bpm)	ST	78.5 ± 4.3	77.8 ± 4.2	−0.9 ↓
	VY + ST	78.2 ± 4.1	74.0 ± 3.9	−5.4 ↓
	AF + ST	78.1 ± 4.2	75.1 ± 4.0	−3.8 ↓

ST = Sprint Training Only; VY + ST = Vinyasa Yoga + Sprint Training; AF + ST = Animal Flow + Sprint Training. ↓ = decrease (improvement in time or heart-rate measure); ↑ = increase (improvement in capacity).

Descriptive statistics (mean ± SD) for all performance and physiological variables at pre-test and post-test for the three groups are presented in Table 2. At baseline, no substantial differences were observed among groups across any measured variable, indicating comparability prior to the intervention. Across the 12-week intervention period, the Vinyasa Yoga plus Sprint Training (VY+ST) and Animal Flow plus Sprint Training (AF+ST) groups demonstrated greater mean changes in all outcome variables compared with the Sprint Training only (ST) group. The ST group showed only minimal changes across performance and physiological measures.

Results of the paired-samples t-tests are summarised in Table 3. The ST group did not demonstrate statistically significant pre–post changes in any performance or physiological variable ($p > .05$), with effect sizes classified as small across all measures. In contrast, both experimental groups exhibited statistically significant within-group improvements ($p < .05$) across all outcome variables. In the VY+ST group, large to very large effect sizes were observed for flexibility, estimated aerobic capacity, 30-m sprint performance, and resting heart rate. The AF+ST group also

Table 3. Within-Group Paired-Samples t-Test Results for Performance and Physiological Variables (N = 45)

Variable	Group	t (df = 14)	p	Cohen's d	Effect Size
30 m Sprint (s)	ST	1.62	.124	0.32	Small
	VY + ST	5.21	< .001	1.35	Large
	AF + ST	5.63	< .001	1.45	Large
Vertical Jump (cm)	ST	1.02	.324	0.21	Small
	VY + ST	6.02	< .001	1.55	Large
	AF + ST	7.18	< .001	1.85	Very large
Agility (s)	ST	0.82	.428	0.18	Small
	VY + ST	4.76	< .001	1.23	Large
	AF + ST	5.03	< .001	1.29	Large
Flexibility (cm)	ST	0.91	.376	0.19	Small
	VY + ST	8.24	< .001	2.13	Very large
	AF + ST	6.97	< .001	1.83	Large
Estimated VO_2max	ST	1.21	.246	0.26	Small
	VY + ST	5.74	< .001	1.46	Large
	AF + ST	4.93	< .001	1.28	Large
Resting HR (bpm)	ST	0.98	.341	0.20	Small
	VY + ST	3.42	.004	0.88	Large
	AF + ST	2.86	.012	0.74	Moderate

Note: Cohen's d: small = 0.20, medium = 0.50, large = 0.80. VO_2max values represent field-based estimates.

demonstrated large within-group effects, particularly for vertical jump height, agility performance, and sprint time. These findings indicate that the addition of either integrative movement-based intervention was associated with greater within-group changes compared with sprint training alone.

One-way ANOVA was used to analyze between-group differences in change scores and the results were tabulated in Table 4. All variables of performance and physiological effects also showed significant group effects ($p < .001$). The magnitude of the differences between groups (η^2_p) ranged between 0.35 and 0.59 representing large effect sizes between groups on the outcomes. The analyses of post-hocs showed that both groups of the experiment had significantly better sprint time (30 m), vertical jump height, agility, flexibility, estimated VO_2max, and resting heart rate compared to the ST group ($p<.01$). There were no statistically significant differences in 30 m sprint performance or in the resting heart rate of VY+ST and AF +ST groups. Nonetheless, specific modality variations were detected in the selected variables. AF+ST group showed much improvement as compared to VY +ST group in vertical jump height and agility performance ($p<.05$). On the other hand, VY+ST group showed far more improvements compared to the AF+ST group on the flexibility and the estimated aerobic capacity ($p<.05$). The cumulative findings suggest that the inclusion of Vinyasa Yoga treatment or Animal Flow sessions in a structured sprint training intervention was currently related to an increase in sprint performance in sprint-related variables, as well as physiological variables, then sprint training alone. Whereas both conditions of the experiment indicated positive adjustments, the response pattern to interventions varied, with flexibility and the estimated aerobic capacity presenting more growth in the VY+ST group and explosive power and agility presenting more increase in the AF+ST group.

Discussion

The aim of the current research was to compare the changes in the sprint-related performance of the adolescent male sprinters and physiological variables changes with the Vinyasa Yoga or Animal Flow exercises plus a structured sprint training programme in comparison to what their sprint training alone achieved. The main results are that both integrative interventions were related to much more significant differences in sprint performance, explosive power, and agility, flexibility, and estimated aerobic capacity and resting heart rate than the control condition. Notably, the adaptation pattern had been varied in the two adjunct modalities implying that the associations between the modalities were not comparable but rather modality-specific. It is an intricate interaction of neuromuscular force generation, intermuscular coordination, and biomechanical efficiency that affects sprint performance, and especially acceleration and maximal velocity (Paradisis et al., 2019; Haugen et al., 2019).

More recent biomechanical theories include the point that performance gains in sprinting are often limited by coordination and movement economy, as opposed to the highest force output per se, particularly in younger athletes (Okudaira et al., 2021; Hicks et al., 2023). In this context, the more significant improvement rates in the both experimental groups can be associated with the increased quality of movement and neuromotor control made possible by the adjunct training modalities. The Vinyasa Yoga and sprint training (VY + ST) condition showed relatively

Table 4. Between-Group One-Way ANOVA on Change Scores for Performance and Physiological Variables (N = 45)

Variable	$F_{(2, 42)}$	p	η^2_p	Effect Magnitude	Post-hoc (Tukey HSD)
30 m Sprint (s)	19.54	< .001	.48	Large	VY + ST < ST*, AF + ST < ST*
Vertical Jump (cm)	27.33	< .001	.57	Large	AF + ST > ST*, AF + ST > VY + ST†
Agility (s)	22.11	< .001	.51	Large	AF + ST < ST*, AF + ST < VY + ST†
Flexibility (cm)	30.62	< .001	.59	Large	VY + ST > ST*, VY + ST > AF + ST†
Estimated VO_2max	24.85	< .001	.54	Large	VY + ST > ST*, VY + ST > AF + ST†
Resting HR (bpm)	11.07	< .001	.35	Large	VY + ST < ST*, AF + ST < ST*

Note: $p < .01$ vs Sprint Training only (ST). † $p < .05$ between experimental groups. $\eta^2_p \geq 0.14$ indicates a large effect.

bigger changes in flexibilities, estimated aerobic capacity and resting heart rate. Unstable joint vascularisation, trunk stability as well as breath-coordinated movements are the focus of dynamic yoga exercises, which can promote more effective movement patterns and autonomic responses (Chaouachi et al., 2008; Polsgrove et al., 2019). Flexibility has been found to increase and various cardiorespiratory variables found to improve with yoga-based interventions in groups of athletes and physically active individuals, but different meta-duration of yoga interventions and intensity result in varying outcomes (Raj et al., 2021; Brunelle et al., 2015).

These current data are aligned with this literature and indicate that the Vinyasa Yoga incorporation can be helpful in terms of physiology adaptation, especially in case of the repeated high-intensity training where recovery and movement economy is of concern. On the contrary, the state of Animal Flow plus sprint training (AF+ST) was related to more positive changes in the vertical jump performance and agility. Movement systems that are quadrupedal and flow-based are demanding on the trunk stiffness, shoulder hip dissociation, and multiplanar force transmission which are essential in explosive and change of direction tasks (Buxton et al., 2020; Ding et al., 2023). It has been shown empirically that quadrupedal movement training has the potential to positively impact the quality of functional movement, dynamic balance, and neuromuscular coordination within rather brief intervention timeframes (Kullman et al., 2020; Buxton et al., 2022). These adjustments can perhaps be converted to high-performance lower limb power expression and agility, as, in the current study, observed. Developmentally, adolescence is a high-growth neuromuscular and musculoskeletal phase, and during it, training responses can be subject to maturation-related factors (Long et al., 2024).

The present study did not directly measure biological maturation and thus, the differences among the observed groups only indicate that integrative movement-based adjuncts can be incorporated to be used alongside traditional sprint training to satisfy the demands of coordination and mobility which are not always comprehensively addressed with the use of sprint-specific drills only. In the development of sprint race in youth, the application of multimodal training methods to lessen the coordination limitation and maximize the movement efficiency has received more support (Nicholson et al., 2021; Skoglund et al., 2023). The found changes in the resting heart rate and the enhancement of estimated aerobic capacity of the VY+ST group are to be seen with some caution. The test was conducted in an indirect way, by measuring aerobic capacity by Cooper 12 minutes run test instead of direct gas analysis, and, thus, indicates the field-based estimates of the true maximal oxygen uptake (Bandyopadhyay, 2014). However, the convergent changes in resting heart rate and predicted aerobic capacity might be evidence of favourable cardiovascular changes or enhanced autonomic balance that have been attributed to mind awake and breathing controlled interventions (Brown & Gerbarg, 2005). These adaptations can help to ensure recovery between sprint bouts and not necessarily raise sprint speed per se.

A number of methodological strengths underlie internal consistency of current findings. The reliability of the observed group differences is enhanced through the use of a randomised controlled design where training protocols are standardised, and tests are carried out under a standard environment. Moreover, the performance-related and physiological variables made it possible to examine training-related adaptations in a wider range without using a single result measure. Presentation of the effect sizes in addition to statistical significance contributes to interpreting practical relevance as well, which is consistent with the modern methodological principles. Yet, there are critical limitations that should be admitted. To begin with, an a priori power analysis has not been performed and the small size of the sample requires the large effect sizes to be interpreted with caution. Second, the biological maturation status was not evaluated and this might have had some effect on the neuromuscular and physiological adaptation in this adolescent group. Third, the aerobic capacity was estimated indirectly and biomechanical or neuromuscular outcomes (e.g., electro-myography or kinematic analysis) were not used to clarify the underlying mechanisms of change. It, therefore, makes it impossible to draw causal conclusions about a particular physiological or biomechanical pathway.

Practically, the results indicate that the inclusion of adjuncts to sprint training programmes which are focused on low- to moderate-intensity movement which does not require a significant increase in training load is a potentially feasible strategy in facilitating performance-related improvements in adolescent athletes. Vinyasa Yoga can be more appropriate at the stage when mobility or recovery needs to be optimal and overall physiological readiness, and Animal Flow can be more appropriate at the stage when explosive power and agility have to be prioritized. Nonetheless, practice should be customised according to the maturity of athletes, their trainings, and work values in general. A number of gaps in the current research are the subject of future research. Relationships between dose and response of integrative movement interventions ought to be investigated and maturation indices should be added to enhance better interpretation among youth population like peak height velocity.

Also, such combinations of field-based performance assessment testing and biomechanical and neuromuscular measurements would allow a better understanding of the mechanisms behind the observed adaptations. External validity would be further benefited by replication of such protocols in female athletes and other sports, which consist primarily of sprint events. Overall, despite the methodological limitations, it is possible to say that the current study has demonstrated that adding Vinyasa yoga or Animal Flow to sprint training is linked with specific and possibly complementary changes in male adolescent sprinters. These results add to the existing research on multimodal and movement-quality-oriented interventions on the athletic development of youth.

Conclusions

The results of the current study are conducive to the point that the combination of Vinyasa Yoga/Animal Flow activities with a strength sprint training programme had higher increases on the chosen variables of performance and physiological parameters in teenage male sprinters than usual sprint training alone did. It was both integrative methods that were associated with positive improvements in sprint performance, explosive power, agility, flexibility, estimated aerobic capacity, and resting heart rate and changes through the 12 weeks intervention. There were clear differences in patterns of adaptation between the two of the adjunct modalities. The conditions of Vinyasa Yoga plus sprint training were more related to the availability of the improvement of flexibility and estimated aerobic capacity alongside the resting HR, and the condition of Animal Flow plus sprint training was more related to the achievement of vertical jumping performance and agility. These results suggest that adjuncts that involve movement can be modality-specific in benefits that can be used as complementary to standard sprint training when implemented in a guided and monitored application. The data must be taken with a grain of salt considering the age of the test subjects who were adolescents, the indirect method of testing aerobic capacity; and the lack of maturation analysis and pre-research power analysis. However, the current research provides the initial evidence in accordance with the possible role of integrative movement practices as the additional portions of youth sprint training programmes. Future studies that use maturation indices, biomechanical studies, and populations should be considered to determine the mechanisms and how to use over patient situations and in other contexts of sport.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

Data Availability

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

Ethical Approval

This study was approved by the Institutional Research Ethics Committee of the Hindustan Institute of Technology and Science (Deemed to be University), Chennai, India (Approval No.: HITS/CRC/004/20603034), and conducted in accordance with the Declaration of Helsinki (2013 revision). Written informed consent and parental consent (for participants under 18 years) were obtained.

Declaration on AI Use

Artificial intelligence–assisted tools were not used in the collection, analysis, or interpretation of data, nor in the generation of scientific content or conclusions. Any language editing, if performed, did not affect the scientific integrity of the manuscript. All scientific responsibility rests solely with the authors.

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Інтегративний вплив вправ Vinyasa Yoga та Animal Flow на спринтерську результативність і фізіологічні адаптації у юних спринтерів чоловічої статі

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 9 с., 4 табл., 24 джерела.

Мета. Метою дослідження було з'ясувати, чи впровадження вправ Vinyasa Yoga або Animal Flow у поєднанні зі структурованою програмою спринтерського тренування забезпечує більші зміни вибраних показників рухової результативності та фізіологічних характеристик у юних спринтерів чоловічої статі порівняно з контрольною групою, яка виконувала лише спринтерське тренування.

Матеріали та методи. У дослідженні взяли участь 45 учнів-спринтерів чоловічої статі старших класів (16,0 ± 0,8 року), яких було випадковим чином розподілено на три групи в межах 12-тижневого рандомізованого експерименту: лише спринтерське тренування (ST), Vinyasa Yoga у поєднанні зі спринтерським тренуванням (VY+ST) та Animal Flow у поєднанні зі спринтерським тренуванням (AF+ST). Усі групи виконували однакову програму спринтерського тренування тричі на тиждень, тоді як експериментальні групи додатково виконували 45-хвилинні допоміжні тренування через день. До показників рухової результативності належали час бігу на 30 м, висота вертикального стрибка та спритність, а до фізіологічних показників — гнучкість, оцінена аеробна працездатність (12-хвилинний біговий тест Купера) та частота серцевих скорочень у стані спокою. Дані до та після експерименту аналізували з використанням парних t-тестів і однофакторного дисперсійного аналізу (ANOVA) для показників змін, із поданням величин ефекту.

Результати. Обидві інтегративні тренувальні групи продемонстрували статистично значуще більші покращення за всіма показниками рухової результативності та фізіологічними змінними порівняно з групою ST ($p < 0,05$). Група VY+ST виявила відносно більші покращення показників гнучкості, оціненої аеробної працездатності та частоти серцевих скорочень у стані спокою, тоді як група AF+ST продемонструвала більший приріст висоти вертикального стрибка та спритності. Для всіх результативних показників зафіксовано великі міжгрупові величини ефекту.

Висновки. Отримані результати свідчать, що доповнення спринтерського тренування вправами Vinyasa Yoga або Animal Flow асоціюється зі сприятливими та модально-специфічними адаптаціями у юних спринтерів чоловічої статі. Такі інтегративні, рухово-орієнтовані підходи можуть слугувати комплементарними стратегіями в системі підготовки юних спринтерів. Водночас, з огляду на непрямий характер оцінки аеробної працездатності, а також відсутність контролю процесів біологічного дозрівання та a priori аналізу статистичної потужності, отримані результати слід інтерпретувати з обережністю.

Ключові слова: Vinyasa Yoga, Animal Flow, спринтерська результативність, інтегративне тренування, юні спортсмени, фізична підготовленість.

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