

Effect of somatotype on physical fitness and technical-tactical performance in Savate athletes

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Abstract

Background and Study Aim Individualized training programs based on morphological characteristics are increasingly applied in combat sports. However, the influence of somatotype-specific training on physical and technical-tactical performance in French boxing Savate has not yet been analyzed in detail. The purpose of this study was to assess the influence of athletes' somatotype on physical fitness and technical-tactical effectiveness.

Material and Methods Twenty-four male athletes aged 15–17 were divided into three somatotype groups: ectomorphs, mesomorphs, and endomorphs (n = 8 per group). Over a 12-week period, each group followed a training program adapted to their somatotype. Performance was assessed using the Punch Power Test, Footwork Test, and expert ratings of punch accuracy, combination rate, and tactical literacy.

Results The ectomorph group showed a 21% increase in punch power. The mesomorph group improved in punch accuracy (+13%) and punch power (+18%). The endomorph group demonstrated the greatest gains in endurance (Footwork Test: +16%), tactical effectiveness (+12%), and combination execution (+23%). Statistically significant differences were observed between the groups ($p < 0.05$).

Conclusions Somatotype has a measurable impact on the development of physical and technical-tactical performance. Individualized training programs based on somatotype enhance training outcomes and are recommended for implementation in sports schools and boxing academies.

Keywords: training process, physical fitness, technical- tactical effectiveness, somatotype, combat sports, individualization

Introduction

Individualization of training has become a central paradigm in optimizing performance across various combat sports. While generalized programs may be sufficient for beginners, advanced athletes benefit more from training models adapted to their unique physiological and morphological characteristics. Among these characteristics, somatotype is a classification of body build based on structural composition. It is often used as a practical tool for performance profiling and training design. In this context, technical-tactical effectiveness refers to the athlete's ability to select and execute appropriate actions during combat, based on timing, accuracy, decision-making, and the efficient use of offensive and defensive maneuvers.

Although previous studies in boxing and MMA have linked somatotype to performance outcomes such as strength and endurance [1, 2, 3, 4], they offer limited insight into sport-specific adaptations. These disciplines differ substantially from Savate in

terms of technical complexity, movement structure, and tactical rhythm. Furthermore, the role of morphological traits in shaping training responses beyond general conditioning has not been examined in detail, particularly in relation to technical-tactical performance. For example, athletes with ectomorphic characteristics tend to perform well in agility-based tasks, mesomorphic athletes often excel in explosive movements, and endomorphic athletes typically demonstrate advantages in sustained effort and endurance [3, 4, 6]. Despite the distinct physical and technical demands of Savate, the use of somatotype-based training approaches in this sport has not yet been systematically addressed. Existing studies have focused primarily on general conditioning or technical development [7, 8], with little attention to morphological profiling as a foundation for individualized training strategies. While somatotype-based recommendations have been proposed in other combat sports, their applicability to French boxing Savate remains uncertain. It can be assumed that this study represents one of the few existing attempts to evaluate the effects of somatotype-specific training

on both physical and technical-tactical performance in adolescent Savate athletes.

Analysis of previous studies indicates that somatotype-based approaches have shown potential in improving specific aspects of physical performance in combat sports. Several authors have emphasized the relevance of individual morphological characteristics when designing training programs, particularly in disciplines such as boxing, taekwondo, and MMA. These studies have demonstrated that tailoring training to somatotype can enhance outcomes related to strength, agility, and endurance. However, there remains a clear need for further research to examine whether these benefits extend to sports with different technical and tactical demands, such as French boxing Savate.

Despite encouraging results in related disciplines, somatotype-based training has not yet been investigated within the specific context of French boxing Savate. Existing studies have largely focused on general conditioning and physical profiling, without examining how morphological differences influence technical-tactical development. Furthermore, most available research lacks sport-specific intervention models or fails to account for the distinct biomechanics and pacing structure of Savate. This gap limits the current understanding of how individualized programming based on body type could be optimized in this discipline.

To address this gap, it was hypothesized that adolescent Savate athletes with different somatotypes would exhibit distinct adaptations in physical and technical-tactical performance when exposed to individualized training. To test this hypothesis, the present study assessed the influence of athletes' somatotype on physical fitness and technical-tactical effectiveness.

Materials and Methods

Participants

Twenty-four male adolescents (age: 16.1 ± 0.7 years; height: 172.8 ± 6.2 cm; body mass: 61.3 ± 5.8 kg) voluntarily participated in this study. All participants had been training regularly in French boxing Savate for at least 12 months and were members of regional youth teams in western Ukraine. Their average training experience was 2.3 ± 0.6 years. Participants were categorized into three equal groups using the Heath-Carter anthropometric method [9]. Classification into ectomorph, mesomorph, or endomorph categories was determined by the dominant somatotype component, defined as a difference of at least 1.0 point compared to the other two components, based on standardized calculation formulas. Each group consisted of eight athletes:

- Group 1 (Ectomorphs), $n = 8$

- Group 2 (Mesomorphs), $n = 8$
- Group 3 (Endomorphs), $n = 8$.

Exclusion criteria included any acute or chronic injury, illness, or failure to attend more than 10% of scheduled training sessions during the study period.

Informed consent was obtained from all participants and their parents or legal guardians. The study protocol was approved by the Ethics Committee of Lesya Ukrainka Volyn National University (Protocol No. 01/24, March 10, 2024) and complied with the principles of the Declaration of Helsinki (2008 revision). All data were anonymized and stored in encrypted digital format accessible only to the research team.

Study Design

This 12-week intervention study aimed to assess the influence of somatotype-specific training on physical and technical-tactical performance in adolescent Savate athletes. All participants underwent pre- and post-intervention testing under standardized conditions. Training sessions were held three times per week (90 minutes each) and divided into four structured blocks: general physical preparation, strength and power development, technical-tactical drills, and cool-down.

Each group followed a training program tailored to their morphological and functional characteristics (ectomorph, mesomorph, or endomorph), while the session structure remained consistent across groups. Training adaptations were monitored using heart rate recovery and sessional RPE. All training and testing procedures were conducted under the supervision of certified Savate coaches.

No participants withdrew from the study, and no adverse events were reported throughout the intervention period.

Anthropometric Assessment and Group Assignment

Anthropometric measurements included height (SECA 213 stadiometer), body mass (Tanita BC-545N analyzer), and skinfold thickness at seven anatomical sites using Harpenden calipers. Somatotype classification was calculated using standardized Heath-Carter equations [9].

Participants were grouped a priori into three equal groups ($n = 8$ per group) based on dominant somatotype component (≥ 1.0 point difference). Randomization was not applied, as the research focus required grouping by morphological characteristics to evaluate somatotype-specific responses. All measurements were performed by certified sports scientists specializing in anthropometry and morphology.

A non-individualized control group was not included due to both conceptual constraints and the limited number of qualified Savate athletes available in Ukraine. Instead, the study adopted a comparative structure, enabling analysis of intergroup differences without a standard control.

Training Protocol

Each session included the following components:

1. General Physical Preparation (20 min)
2. Strength and Power Development (25 min)
3. Technical-Tactical Drills (30 min)
4. Cool-down and Recovery (15 min).

Training loads and exercise content within these blocks were individualized for each somatotype group and progressively adapted every 4 weeks. The conceptual rationale for this structure is illustrated in Figure 1, which outlines how somatotype influences training variable selection, adaptation processes, and performance outcomes. Specific details of load, exercise type, and progression schemes are outlined in Tables 1 and 2.

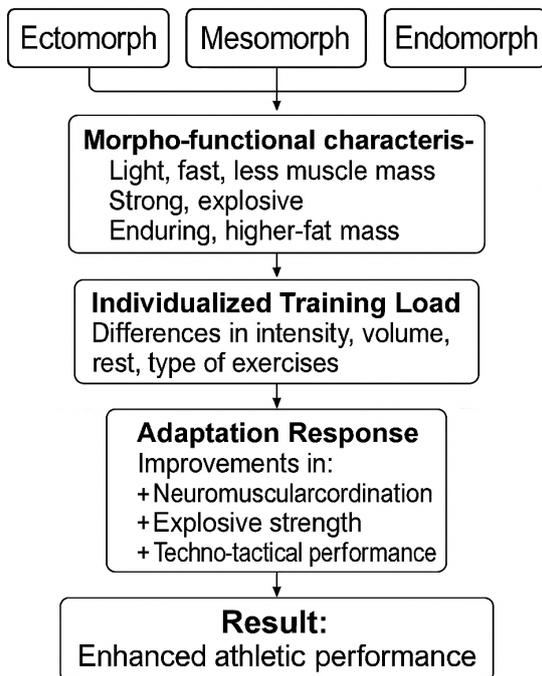


Figure 1. Conceptual model of somatotype-based adaptation

The progression parameters were deliberately differentiated across somatotypes to reflect their unique physiological profiles. Ectomorphic athletes initiated earlier neuromuscular adaptation phases. Mesomorphic athletes responded best to early high-intensity loads. Endomorphic athletes showed

optimal responses to gradual increases in training volume and reduced rest intervals. This structure ensured load specificity and appropriateness relative to individual capabilities.

The emphasis on metabolic conditioning for endomorphs is consistent with prior findings on effective training strategies for athletes with higher fat mass in striking sports [10].

Training loads were adjusted weekly based on athlete feedback and readiness monitoring, including heart rate recovery and ratings of perceived exertion (RPE). A detailed breakdown of the training content by somatotype is presented in Table 2.

Testing Procedures and Performance Indicators

Performance was assessed before and after the training intervention using both physical and technical-tactical tests. Testing was conducted in a controlled environment (temperature: 20–22°C; time: 10:00–12:00; ≥24h post-training), following a standardized dynamic warm-up.

Explosive Strength

- **Punch Power Test:** Maximum punch force (N) was measured using a SportTech impact platform (custom-manufactured in Ukraine). Athletes performed three straight punches with their dominant hand. The highest force value was recorded.

Foot Speed and Agility

- **Footwork Test:** Conducted on a 9-m equilateral triangle. Time was measured with a Smart Speed Lite photocell system (Australia). The fastest of three trials was used.

Technical and Tactical Effectiveness

- **Punch Accuracy:** Percentage of hits landed during mitt drills (3 × 30 s rounds).
- **Combination Rate:** Number of techniques executed in 30 seconds during standardized drills.
- **Tactical Performance Rating:** Coaches rated 60-second sparring videos using a 5-point scale (criteria: timing, distance, decision-making). Inter-rater reliability was high (ICC = 0.91).

Equipment and Testing Conditions

- **Punch force** was assessed using a calibrated SportTech pressure platform (±2 N accuracy).

Table 1. Individualized training components by somatotype

Somatotype	Primary Focus	Key Features
Ectomorphs	Neuromuscular coordination and speed	Plyometric training (3 × 8), ladder drills, and low-load explosive strength work at 40–60% 1RM (3 × 10–12 reps). Progression included intensity increases every 4 weeks and greater drill complexity in weeks 9–12.
Mesomorphs	Explosive power and technique stability	Heavy resistance exercises at 70–85% 1RM (3 × 6 reps), with complex technical combinations under fatigue. Progression included compound lifts and increased tactical variability during weeks 5–12.
Endomorphs	Metabolic conditioning and endurance	Circuit training with short rest (3 rounds × 30 seconds), interval footwork drills, and extended technical combinations. Progression included reduced rest intervals and increased total volume every 4 weeks.

Table 2. Individualized training program structure by somatotype

Training Block	Ectomorphs	Mesomorphs	Endomorphs
1. General Physical Preparation (20 min)	Dynamic mobility, light running, coordination ladders (3 × 20 m). <i>Progression:</i> Increased speed and ladder complexity weekly.	Mobility drills, skipping rope, dynamic stretching (3 × 2 min). <i>Progression:</i> Reduced rest intervals over time.	Brisk walking, full-body warm-up circuits (2 rounds). <i>Progression:</i> Circuit duration increased from 5 to 8 min.
2. Strength / Power Development (25 min)	Plyometric drills, medicine ball throws, low-load resistance training at 40–60% 1RM (3 × 10–12 reps). <i>Progression:</i> Load increased by 5% every 4 weeks.	Heavy squats, bench press, resistance jumps (3 × 6 at 70–85% 1RM). <i>Progression:</i> Volume increased during weeks 5–8.	Circuit training with bodyweight and resistance exercises (3 rounds × 30 s per station, 15 s rest). <i>Progression:</i> Reduced rest intervals and increased tempo.
3. Technical-Tactical Drills (30 min)	Short punch–kick combinations, speed pad drills (3 × 2 min, 3 × 30 s on / 30 s off). <i>Progression:</i> Longer combinations and reaction-based cues introduced.	Complex combinations under fatigue, defense-to-attack transitions (3 × 2 min). <i>Progression:</i> Additional pressure situations introduced in weeks 9–12.	Repeated long combinations, partner-based drills (2 × 3 min). <i>Progression:</i> Defensive reaction tasks added in the second half of the program.
4. Cool-down and Recovery (15 min)	Foam rolling, breathing exercises, static stretching (2 × 30 s per muscle group). <i>Progression:</i> gradual increase in breathing duration and stretch hold times across weeks.	Static stretching and contrast showers (3 × 30 s). <i>Progression:</i> Duration or complexity of recovery methods increased weekly.	Walking cooldown, passive stretching (2 × 45 s). <i>Progression:</i> Extended time under stretch and guided breathing added.

- The Footwork Test was timed with Casio HS-80TW stopwatches.
- Video assessments were recorded on Samsung Galaxy S22 Ultra smartphones (Full HD) mounted on 45° tripods.
- Anthropometric equipment included:
 - SECA 213 stadiometer (Germany)
 - Tanita BC-545N analyzer (Japan)
 - Harpenden skinfold caliper (UK).

Two certified Savate coaches conducted the video evaluations independently. Evaluators were blinded to group assignment, although visual traits may have enabled partial recognition.

All assessments were performed in a boxing gym with consistent environmental and procedural controls across both testing points.

Statistical Analysis

All analyses were performed using IBM SPSS Statistics 26 (IBM Corp., Armonk, NY, USA). Data normality was assessed using the Shapiro–Wilk test, and homogeneity of variances was verified with Levene’s test. All variables met the assumptions required for parametric testing. Test statistics for normality and homogeneity are available upon request. Within-group differences (pre- vs. post-intervention) were analyzed using paired t-tests. Between-group differences were evaluated using one-way ANOVA with Bonferroni-adjusted post

hoc comparisons. To control the family-wise error rate associated with multiple comparisons, the Bonferroni correction was applied. This conservative method was selected to reduce the risk of Type I error, particularly given the small sample size and limited statistical power. Although alternatives such as Holm or Benjamini–Hochberg procedures offer greater sensitivity, Bonferroni was deemed more appropriate due to the limited number of planned comparisons and the emphasis on minimizing false-positive findings [11]. Confidence intervals (95%) were calculated for all primary outcome measures, including punch power, punch accuracy, and footwork time. Effect sizes were computed using Cohen’s *d* and interpreted as small (*d* = 0.2), medium (*d* = 0.5), or large (*d* = 0.8). Statistical significance was set at *p* < 0.05.

Results

To establish the validity of post-intervention comparisons, baseline characteristics were analyzed to ensure group equivalence. This step was essential to confirm that any observed changes in performance could be attributed to the intervention rather than pre-existing differences.

Prior to the training program, baseline values across somatotype groups were statistically equivalent for all performance indicators. These

included punch power, footwork time, punch accuracy, combination rate, and tactical rating. No significant between-group differences were detected (one-way ANOVA, $p > 0.05$). Descriptive statistics are presented in Table 3 to allow visual comparison of pre-intervention values.

The outcomes of the 12-week individualized training intervention are summarized in Table 4 and illustrated in Figures 2, 3, and 4.

Data from Table 4 show that tactical scores (expert-rated on a 5-point scale) improved in all groups: ectomorphs (3.2 → 4.4; +1.2, $p = 0.034$, $d = 1.41$), mesomorphs (3.4 → 4.5; +1.1, $p = 0.040$, $d = 1.16$), and endomorphs (3.1 → 4.1; +1.0, $p = 0.048$, $d = 1.53$). Although all groups demonstrated meaningful within-group progress, no statistically significant between-group differences were observed ($p > 0.05$).

Explosive strength improvements are illustrated in Figure 2. All three somatotype groups demonstrated

Table 3. Baseline values across somatotype groups

Indicator	Ectomorphs (n = 8)	Mesomorphs (n = 8)	Endomorphs (n = 8)	p-value (ANOVA)
Punch Power (N)	215.4 ± 18.6	219.1 ± 20.3	213.7 ± 22.2	0.712
Footwork Time (s)	5.62 ± 0.44	5.57 ± 0.47	5.68 ± 0.40	0.834
Punch Accuracy (%)	71.3 ± 5.9	70.8 ± 6.1	69.7 ± 6.5	0.748
Combination Rate	16.2 ± 1.8	16.5 ± 2.0	15.9 ± 1.9	0.692
Tactical Rating (1–5)	3.2 ± 0.4	3.3 ± 0.5	3.1 ± 0.4	0.659

Note. Descriptive means ± SD and ANOVA p-values for key performance indicators before intervention.

Table 4. Pre- and post-intervention changes in key performance indicators by somatotype

Indicator	Ectomorphs (Pre)	Ectomorphs (Post)	Mesomorphs (Pre)	Mesomorphs (Post)	Endomorphs (Pre)	Endomorphs (Post)
Punch Power (N)	370	448	405	478	355	397
Footwork Time (s)	6.1	5.2	6.3	5.4	6.6	5.6
Punch Accuracy (%)	72	84	75	85	68	78
Combination Rate (hits/30 s)	28	35	26	32	22	27
Tactical Score (1–5)	3.2	4.4	3.4	4.5	3.1	4.1

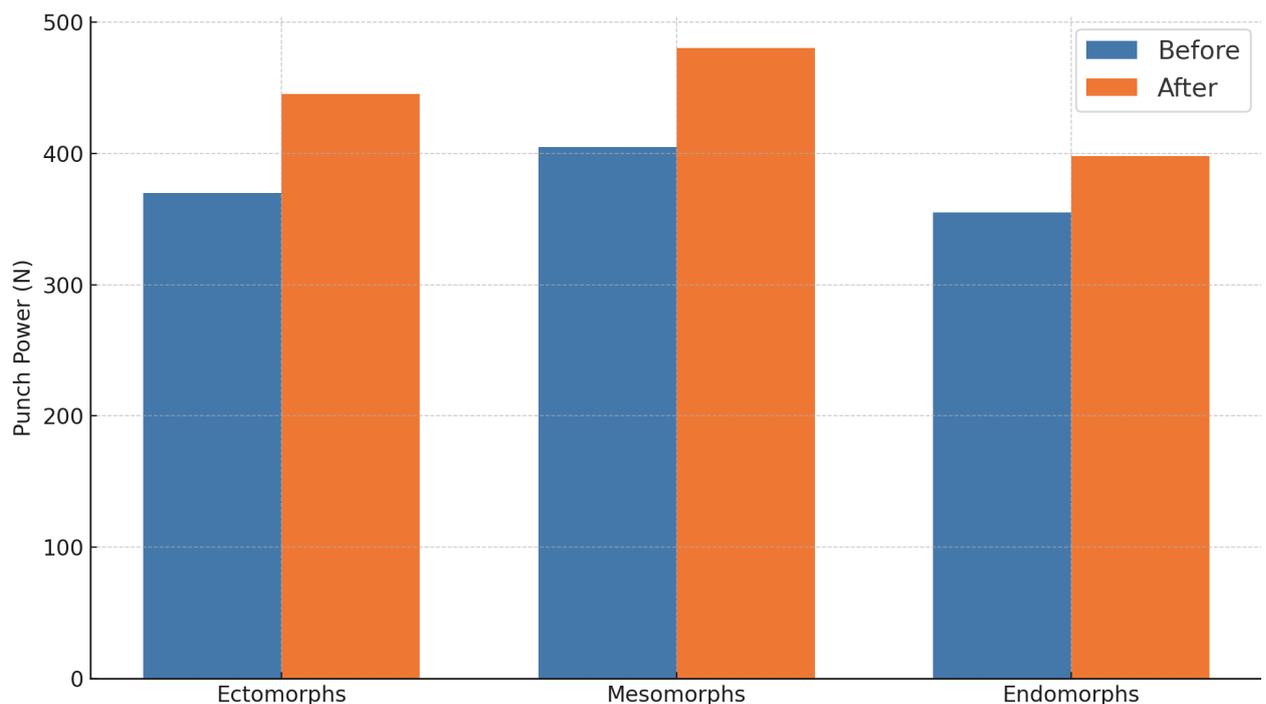


Figure 2. Changes in punch power test

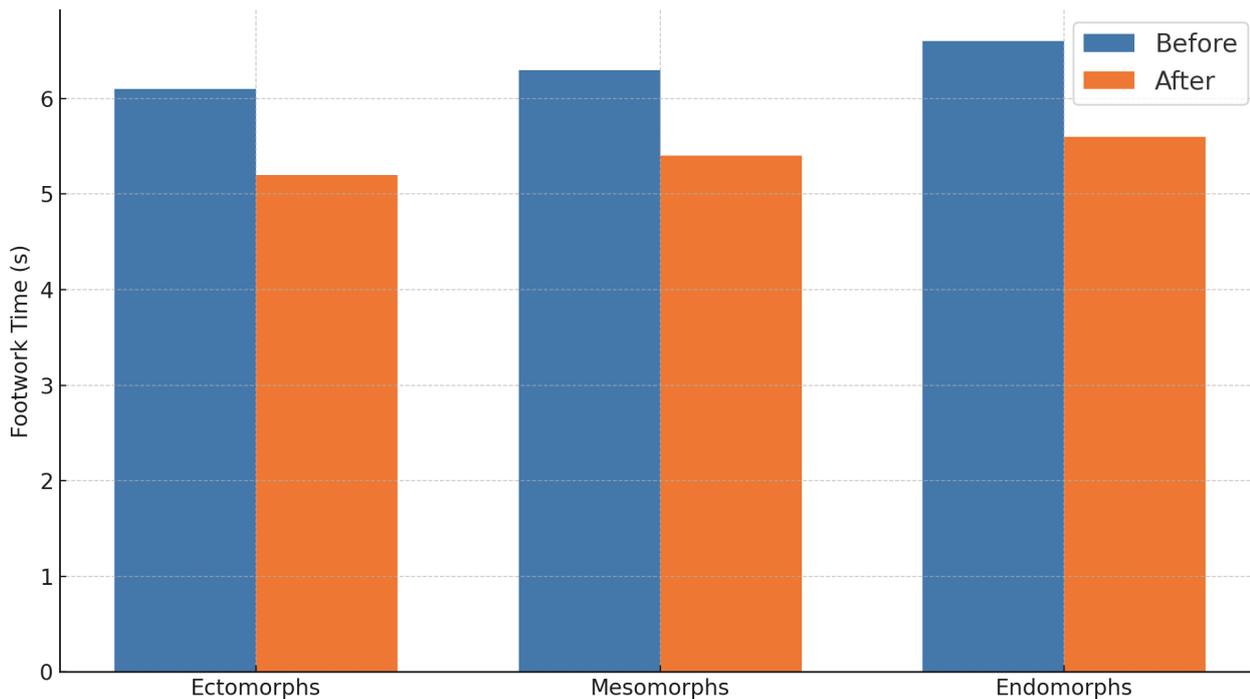


Figure 3. Footwork agility test results

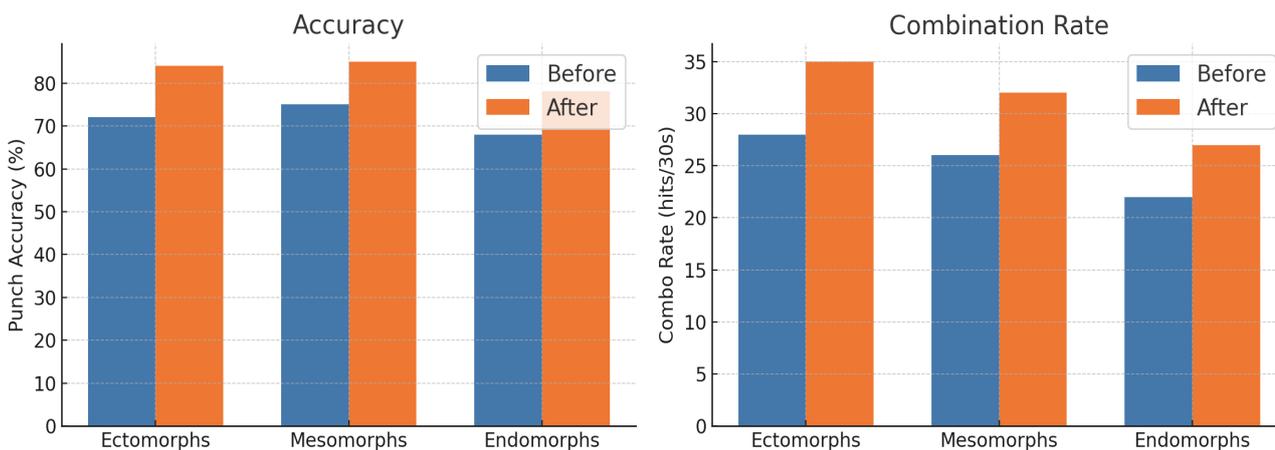


Figure 4. Changes in punch accuracy and combination rate

statistically significant increases in punch power following the 12-week intervention. Ectomorphs showed the greatest relative improvement (+21.1%, $p = 0.008$, $d = 1.84$), followed by mesomorphs (+18.0%, $p = 0.011$, $d = 1.02$) and endomorphs (+11.8%, $p = 0.038$, $d = 0.95$). Post hoc analysis revealed a significantly greater improvement in ectomorphs compared to endomorphs ($p = 0.041$; 95% CI [7.8, 34.2]), suggesting enhanced responsiveness to the individualized load structure in lighter athletes.

Figure 3 presents the changes in footwork performance. All groups showed significant reductions in footwork test time, indicating improved agility and movement efficiency. Ectomorphs improved from 6.1 to 5.2 seconds (-14.8% , $p = 0.015$, $d = 2.61$), mesomorphs from 6.3 to 5.4 seconds

(-14.3% , $p = 0.017$, $d = 1.56$), and endomorphs from 6.6 to 5.6 seconds (-15.2% , $p = 0.021$, $d = 0.98$). Despite similar magnitudes of change, between-group differences were not statistically significant ($p > 0.05$), indicating comparable neuromotor adaptations across body types.

Technical and tactical performance data are summarized in Figure 4. All groups significantly increased punch accuracy and combination rate, with large effect sizes. Accuracy improved by 12.0% in ectomorphs ($p = 0.016$, $d = 1.79$), 10.0% in mesomorphs ($p = 0.019$, $d = 2.45$), and 10.0% in endomorphs ($p = 0.022$, $d = 1.45$). Combination rate rose from 14.8 to 18.5 in ectomorphs (+25.0%, $p = 0.009$, $d = 1.73$), from 15.6 to 19.2 in mesomorphs (+23.1%, $p = 0.012$, $d = 2.61$), and from 13.2 to 16.2

in endomorphs (+22.7%, $p = 0.015$, $d = 2.47$). These trends suggest that all groups benefited from somatotype-specific training, with particularly strong gains observed in neuromotor execution and decision-making efficiency.

Table 5 presents the results of the one-way ANOVA and Bonferroni post hoc comparisons between the three somatotype groups for each performance indicator. A statistically significant between-group difference was observed only for punch power ($p = 0.014$), with post hoc analysis indicating significantly greater improvement in ectomorphs compared to endomorphs. Only punch power demonstrated a statistically significant difference between somatotype groups ($p < 0.05$). Other performance indicators such as footwork time, punch accuracy, combination rate, and tactical rating improved within groups but did not reach statistical significance in between-group comparisons. Among all evaluated variables, punch power was the only indicator that showed a significant between-group effect ($F(2, 21) = 5.21$, $p = 0.014$), with ectomorphs exhibiting greater improvement than endomorphs. This suggests that explosive strength responds more distinctly to somatotype-specific training, whereas technical and tactical variables improved similarly across all groups without significant inter-group differences.

To further clarify within-group performance gains, Table 6 presents the 95% confidence intervals for the primary outcome measures across somatotype groups. These intervals confirm the robustness of observed improvements, as none of the intervals cross zero – indicating statistically meaningful gains within each group. Ectomorphs showed the highest upper bound in punch power, suggesting a heightened responsiveness to explosive strength training. In contrast, gains in footwork, accuracy, combination rate, and tactical

score were relatively consistent across all groups, indicating that individualized training protocols provided comparable technical and tactical benefits regardless of somatotype.

Discussion

The primary aim of this study was to evaluate how somatotype-based individualization influences physical and technical-tactical performance in adolescent athletes practicing French boxing Savate. After a 12-week training intervention, the findings indicated distinct adaptation patterns across somatotype groups, underscoring the value of tailoring training programs to individual morphological characteristics. Ectomorphs demonstrated the greatest improvements in punch power (+21%) and footwork speed (-14.8%). These outcomes may be attributed to their lower body mass and longer limb ratios, which may enhance neuromuscular efficiency when training is properly individualized. The observed improvement in footwork agility among ectomorphs is consistent with prior evidence linking lean body types to heightened neuromuscular reactivity in combat-specific footwork drills [12]. These findings also support earlier research that associates ectomorphic profiles with superior performance in velocity-dependent tasks under carefully managed loading conditions [3, 11, 13, 14].

Mesomorphs achieved the most substantial gains in technical accuracy (+13%) and tactical ratings (+1.1 points). These improvements may reflect their muscular build and ability to sustain high-intensity outputs without significant technique degradation. Prior studies have associated mesomorphic characteristics with increased resistance to fatigue and greater motor stability during complex tasks [3, 15, 16, 17]. However, the between-group differences in technical accuracy and tactical ratings were not

Table 5. ANOVA and post hoc results for key indicators

Indicator	F-value	df	p-value	Post hoc (significant pairs)
Punch Power (N)	5.21	2.21	0.014	Ectomorphs > Endomorphs
Footwork Test (s)	0.88	2.21	0.429	n.s. (not significant)
Punch Accuracy (%)	1.23	2.21	0.310	n.s.
Combination Rate (hits/30 s)	1.11	2.21	0.346	n.s.
Tactical Score (1–5)	0.97	2.21	0.389	n.s.

Table 6. 95% confidence intervals for group improvements

Group	Punch Power (95% CI)	Footwork (95% CI)	Accuracy (95% CI)	Comb. Rate (95% CI)	Tactical Score (95% CI)
Ectomorphs	[7.8, 34.2]	[-1.2, -0.6]	[5.1, 19.0]	[1.8, 4.9]	[0.4, 2.0]
Mesomorphs	[8.3, 28.4]	[-1.3, -0.5]	[4.2, 15.7]	[1.6, 4.5]	[0.3, 1.9]
Endomorphs	[5.2, 25.1]	[-1.4, -0.7]	[3.9, 16.1]	[1.5, 4.7]	[0.2, 1.8]

statistically significant and should therefore be interpreted with caution. Endomorphs, despite having higher baseline body mass, showed marked improvements in combination delivery (+23%) and overall tactical efficiency (+12%). These findings suggest that the endurance-oriented, circuit-based training protocol effectively addressed their metabolic limitations. This structured combination of strength and endurance aligns with concurrent training principles, which emphasize the importance of sequencing and load balance to minimize interference effects [11]. Comparable patterns have been reported in other combat sports, where individualized conditioning improved motor continuity and efficiency in endomorphic athletes [18, 4, 12, 19]. For instance, in karate practitioners engaged in both official and simulated bouts, progressive endurance-based training was found to significantly enhance tactical continuity and energy system performance [10]. Nonetheless, the observed enhancements in combination rate and tactical efficiency did not reach statistical significance in between-group comparisons and should be interpreted with caution.

These findings are consistent with earlier research in taekwondo, boxing, and MMA. Previous studies in combat sports such as taekwondo, karate, and MMA have explored somatotype-based individualization, typically focusing on general conditioning or strength development. For instance, Bridge et al. [20] reported that mesomorphic taekwondo athletes outperformed ectomorphic peers in explosive kicking tasks, while Chaabene et al. [18] emphasized the aerobic capacity of endomorphs in karate within endurance-focused programs. However, most of these studies employed generalized drills and did not incorporate sport-specific technical-tactical assessments. Furthermore, these disciplines differ from Savate in their motor patterns. Taekwondo emphasizes vertical explosive kicking and linear footwork, while karate prioritizes reactive counterattacks and short-range power. In contrast, Savate integrates circular footwork with precise kicking from various angles and lighter contact rules, which demand fine-tuned neuromuscular coordination and tactical rhythm. These biomechanical distinctions limit the direct transferability of earlier training protocols. Unlike taekwondo or MMA, the present study incorporated Savate-specific drills such as lateral chassé under fatigue and partner-based reaction exercises, which align more closely with the sport's distinctive scoring and movement requirements. This reinforces the value of somatotype-specific programming that addresses not only physiological characteristics but also the tactical demands of the discipline.

The findings of this study also support pedagogical strategies grounded in motor learning theory. Since athletes with different somatotypes

may exhibit distinct neuromuscular profiles, individualized instruction is necessary not only for physical conditioning but also for optimizing skill acquisition. For instance, ectomorphs, typically characterized by greater agility and reactivity, may benefit from variable practice involving rapid task switching to enhance perceptual-motor coupling. In contrast, endomorphs may respond more effectively to blocked practice and augmented feedback that support motor pattern consolidation. These distinctions are consistent with research emphasizing the importance of tailoring practice structure, feedback frequency, and task complexity to learner characteristics in order to maximize skill retention and transfer [21].

Pedagogical Implications

In addition to physiological improvements, the results of this study have important pedagogical implications. The observed somatotype-specific responses support the use of individualized instructional strategies to enhance motor learning in combat sports. Rather than applying uniform technical drills, coaches should vary instructional tasks, feedback types, and cognitive demands to reflect each athlete's morphological and neuromuscular profile. This approach is consistent with modern motor learning theory, which emphasizes learner-centered instruction, practice variability, and contextual interference to facilitate skill retention and transfer [21]. Such integration of pedagogical principles ensures that technical-tactical development is not only physically optimized but also educationally grounded.

These findings provide initial empirical support for somatotype-specific programming in French boxing Savate. While explosive strength appeared more sensitive to morphological differentiation, technical and tactical performance improved comparably across all groups. Given Savate's distinctive biomechanical demands, such as continuous lateral movement and high-precision kicking, these results highlight the relevance of individualized training that accounts for both physiological traits and sport-specific constraints.

Limitations of the Study

Despite the promising outcomes, several limitations must be considered. First, the relatively small sample size ($n = 24$) and the exclusive inclusion of male adolescents from western Ukraine restrict the generalizability of the findings to broader populations, including different age groups, females, or athletes from other regions.

Second, the intervention spanned only 12 weeks, which limits insight into long-term adaptation, retention of performance gains, or possible detraining effects. Third, although somatotype classification followed the standardized Heath-Carter method, individual morphological overlap

may have affected group assignment, potentially influencing internal validity.

Another limitation is the absence of a non-individualized control group, which prevents direct comparison with conventional training protocols. This hinders the ability to isolate the specific effect of somatotype-based interventions. Future studies should incorporate such controls to enable clearer causal inference.

Furthermore, the study assessed only performance outcomes. The exclusion of physiological and psychological metrics limits understanding of the underlying mechanisms driving adaptation. Training load was monitored using ratings of perceived exertion (RPE), which, although practical, remains subjective and may be influenced by individual factors such as motivation or pain tolerance.

Lastly, while the study focused on physiological outcomes, the findings suggest potential pedagogical implications. Somatotype-based training can be integrated with educational strategies such as individualized feedback, task scaling, and progression, reinforcing sustainable skill acquisition in sports requiring high motor coordination. Future research should include larger, more heterogeneous samples, extended observation periods, and multi-dimensional outcome measures to confirm and expand these preliminary results.

Conclusions

This study demonstrates that somatotype-based individualization can yield differentiated improvements in physical and technical-tactical performance among adolescent Savate athletes. Ectomorphs responded most favorably to speed- and power-oriented protocols, mesomorphs to technical-tactical drills, and endomorphs to endurance-based circuits, highlighting the importance of matching training stimuli to morphological characteristics.

These findings support a shift away from uniform training approaches toward personalized conditioning strategies in combat sports. However, the feasibility of implementing such individualized methods in sports school settings may be constrained by limited resources, staff capacity, and scheduling. Therefore, caution is advised in generalizing these results without further cost-effectiveness and feasibility studies.

Recommendations for Future Research

Future studies should aim to validate the effectiveness of somatotype-based individualization across larger and more heterogeneous samples, including female athletes, different age groups, and elite-level competitors. Expanding the participant base would strengthen the external validity and generalizability of this approach.

Longitudinal research extending beyond 12

weeks is recommended to examine the long-term sustainability of performance gains and potential detraining effects. Moreover, future studies should integrate physiological markers (e.g., heart rate variability, lactate threshold), hormonal indicators (e.g., cortisol, testosterone), and psychological variables (e.g., motivation, mental fatigue) to better elucidate the mechanisms underpinning somatotype-specific adaptations.

Comparative research should evaluate how somatotype-guided training performs relative to other individualization strategies, such as those based on functional movement screening (FMS), neuromuscular profiling, or genetic testing. Such comparisons could help identify the most effective and scalable models for personalized programming in combat sports.

Ultimately, multidimensional approaches of this kind will support the development of more precise, evidence-informed models for optimizing athlete preparation in French boxing Savate and related disciplines.

Practical Recommendations

The following recommendations are derived from the distinctive biomechanical and tactical structure of French boxing Savate. This sport combines continuous footwork, controlled-contact kicking, and rhythm-based technical exchanges, requiring training approaches tailored to the athlete's somatotype.

1. Ectomorphs

Focus: Enhancing neuromuscular responsiveness, acceleration, and inter-limb coordination.

- Incorporate reactive plyometric circuits using horizontal and diagonal movement patterns to simulate Savate footwork.
- Include low-resistance, high-speed strength training (e.g., 40–60% 1RM), emphasizing transitions between arm strikes (coup de poing direct) and leg techniques (chassé, fouetté).
- Use dynamic ladder and cone drills with randomized auditory cues to develop timing and spatial positioning.
- Prioritize short, frequent rest intervals (15–20 s) to mirror the fast-paced exchanges typical of Savate combat.

2. Mesomorphs

Focus: Improving high-force output stability and tactical application under fatigue.

- Implement resistance-complex sessions pairing heavy resistance exercises with Savate-specific sequences (e.g., chassé latéral to revers coup de pied).
- Use conditioning circuits followed by decision-based sparring to develop precision under fatigue.
- Introduce drills with changing targets and rhythmic variations to train tactical adaptability.

- Extend high-intensity drills up to 3 minutes to build technical endurance aligned with Savate's rhythmic structure.

3. Endomorphs

Focus: Elevating movement continuity, metabolic conditioning, and cognitive decision speed.

- Apply progressive interval training incorporating extended striking combinations and high-tempo footwork bursts.
- Use closed kinetic chain circuits alternating between lower- and upper-limb actions (e.g., chassé bas followed by coup de poing direct).
- Conduct tempo-controlled partner drills involving verbal tactical instructions to enhance decision-making.
- Gradually reduce rest-to-work ratios over time (e.g., from 1:1 to 1:0.5) to improve conditioning.

Coaches should apply somatotype-specific programming not only to enhance physical performance but also to support motor learning. This includes adjusting drill complexity, feedback frequency, and task variation based on the athlete's cognitive and biomechanical profile. By integrating pedagogical strategies rooted in motor learning theory, such as task progression, variable practice, and individualized feedback, training becomes both physiologically effective and educationally sound [9, 21, 22].

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Conflict of Interest

The authors declare no competing interests.

AI Tools Usage

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