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Somatotype Profiles and their Relationship to Swimming Motor Skills in Undergraduate Sports Training Students

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Abstract

The purpose of this study is to investigate the relationships between somatotype components and fundamental swimming skills among undergraduate students specializing in sports training, swimming track.Forty-two male aged 17 to 20 took part in this study. Somatotypes were determined using the Heath-Carter anthropometric method. Swimming skills, were assessed using standardized tests. A significant differences were found across somatotype groups for all swimming skills ($p<0.01$). Mesomorphic students demonstrated superior propulsion, with significantly longer glide distances and better swimming index compared to ectomorphs and endomorphs. Endomorphic individuals exhibited greater buoyancy but reduced propulsion efficiency and slower swim speeds. Pearson correlations indicated that mesomorphy positively correlated with glide ($r=0,68$) and swimming index ($r=0,72$),while endomorphy correlated positively with buoyancy ($r=0,75$) but negatively with propulsion ($r=-0,70$). Somatotypes significantly impact swimming motor skill proficiency among late-learning students.These findings support the incorporation of morphology informed, individualized swimming instruction strategies to optimize motor skill acquisition and performance.

Keywords : Swimming, Somatotype, Motor skills, Sport training.

Introduction

Drawing on fundamental knowledge from disciplines such as physiology psychology, and morphology, sport science explores the complex relationships between the physical, technical, and tactical factors underlying athletic performance. As scientific understanding has expanded, these insights have contributed significantly to advances in physical education and sport, particularly in curriculum design, instructional strategies, and talent identification across different age groups and performance levels. Swimming is a fundamental activity, distinguished by its high level of motor skills and overall health benefits. Unlike traditional sports, swimming requires the integration of complex biomechanical movements, breath control, and adaptation to the aquatic environment. Effective swimming performance depends on the swimmer's ability to optimize motor control and coordinate fluid movements to achieve specific goals. The acquisition and refinement of motor skills are necessary, such as starts, gliding, stroke mechanics, and turns are therefore essential and rely on the ineraction of multiple physiological and biomechanical factors (Zampagni, & al., 2008).

A growing area of interest in sport and exercise science concerns individual variations in body constitution, commonly described by the concept of somatotype, and their potential influence on motor proficiency and skill development. The somatotype model, developed by Sheldon and revised by Heath and Carter, classifies individuals into three primary components (ectomorphs; mesomorphs; endomorphic) (Carter & Heath, 1990). Previous studies suggest that somatotype characteristics may

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predispose individuals to certain physical and confer advantages or limits in specific sports contexts. (Touami, & al., 2025; Mimouni, & al., 2021; Sadouki, 2018)

In swimming, somatotype is beleved to be closely associated with both performance outcomes and motor skill aquisition. A mesomorphic body type, characterised by greater muscle mass and strength, may enhance propulsion and power generation during swimming strokes. In contrast, ectomorphic swimmers, due to their linear body structure, may benefit from impoved body alignment and movement efficiency in the water, potentially reducing hydorodynamic drag and energy expenditure. Conversly, increased fat mass associated with endomorphy may impair hydrodynamic efficiency by increasing frontal resistance and may hinder the acquisition of motor skills.

Algerian Institutes of science and techniques of physical and sports activities (S.T.A.P.S) are responsible for training qualified professionals capable of intervening across various domains of sport and physical activity, swimming is considered as one Topic of the core skills to be taught from the first cycle , however, a large proportion of students (75% -85%) have limited or no prior swimming experience. This is partly due to the limited integration of swimming within earliers stages of formal education. Consequently, swimming instruction often begins relatively late, between the ages of 18 to 21 years, despite evidence suggesting that early childhood represents an optimal period for learning complex motor skills (Langendorfer & Bruya, 1995).

Late initiation into swimming is associated with significant challenges in the acquisition of fundamental swimming motor skills (floating, immersion, leg kicks, and arm movements). Moreover, the student population is highly hetrogeneous in regard to anthropometric dimensions and somatotypes. Considering the morphological diversity and delayed exposure to swimming, an imortant question remains : to what extent does somatotype influence success in acquiring fundamental swimming motor skills?

Based on this quetion and previous research, it is hypothesized that students' somatotype classification (ectomorph, mesomorph, endomorph) has significant relationship with their proficiency in fundamental swimming motor skills. More speciffically mesomorphic students, characterized by greater muscle mass and strength, are expected to perform better in related skills such as stroke propulsion.Ectomorph students will have better scores to motor skills for support force and fluidity of water movements. Conversly endoformic students might be faced with more problems in acquiring the skills, which require longer propulsion time and streamline skill due to elevated fat composition.

Addressing this deficiency hypotheses may contribute to the development of more individualized and effective teaching formats, which in turn can help people in learning outcomes and maximize swimming learning effect in students. This study aims to investigate the relationship between somatotype components and motor skills in students swimmers enrolled in professional coaching program involving both theoretical and practical training.

1.1. Literature Review

Recent findings consistently show that swimming performance and skill learning are strongly affected by both physiological and anthropometrical aspects, because somatotype has been a widely used determinant of the performances capacity and adaptations experienced in practise. Studies in the last five years have characterised different somatotypic traits that seem to be associated with swimming performance: among these, trunk length, muscle mass and body composition are reported to be related with swimming proficiency, as mesomorphic or ectomorfous people often appear to take specific benefit from propulsion or buoyancy force (Rejman & al., 2023 ; Dos Santos & al., 2021).

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The literature reports that motor learning in swimming is more favorable in young age from 5 to 6 years old, due the increase of neural plasticity and the enhancing of motor pattern consolidation (Minkels & al., 2025). When swimming teaching begins at a later stage, for instance among university students, pupils typically encounter slower rates of improvement and greater motor coordination challenges while mastering aquatic skills along with much greater individual variability compared to considering body morphology alone

In 2024, a systematic review by Todd Price & al. concluded that anthropometric factors (with the inclusion of somatotype and body composition) appear to be among the best predictors for technical efficiency and swimming performance in adolescents and young adults. Large scale allometric modeling studies support these conclusions and suggest that body type can determine the effectiveness of standardized swim instruction programs (Rejman & al., 2023). This implication is apparently supported by the fact that differences in somatic shape are likely to be one factor underlying the enduring gap in movement skill acquisition when instruction takes place beyond early childhood.

In general, these emerging findings illuminate the demand to develop sports science curriculums and coaching programmes for university students which have taken into account with their varying morphological patterns as well as late learning window. Knowledge about the interaction between somatotype and learning of swimming skills could be useful to individualize teaching programmes, avoid any inequity in motor attainment.

1. Method and Materials

2.1. Study design

In line with the objectives, a cross-sectional research design was employed to examine the relationship between somatotype profiles and swimming related motor skills among students specializing in sports training. This design enabled a descriptive and correlational analysis.

2.2. Participants

A total of forty-two male undergraduate students aged between 17 and 20 years (18,71 ± 1,16) took part in this study. They were third-year students enrolled in the sports training track, with a specialization in swimming, at STAPS, Souk-Ahras University. Prior to participation, all students had completed a one-semester swimming training program as part of the first-year common core curriculum. which included practical swimming sessions of 90 minutes each. Due to the applied nature and practical constraints of the study, a non-probability sampling method, namely availability sampling, was used. Participants were selected based on their accessibility and willingness to participate. Those with excessive absences from swimming classes or current illnesses were excluded to ensure the reliability of the data and the feasibility of the research procedures.

2.3. Data Collection method

2.2.1 Anthropometric Measurements and somatotypes Assessment

Participant’s somatotypes were estimated using the Heath-Carter (1990) method. Body mass (kg) and height (cm) were mrasured using a calibrated scale and stadiometer, respectivly. Skinfold thicknesses in millimeters (triceps, subscapular, suprailiac, and medial calf) were measured using a Harpenden caliper on the right side of the body, with participants standing upright. Circumferences (cm) : flexed and tensed arm, and maximum calf, as well as humerus and femur diameters (cm) were measured using a flexible tape and bone caliper following standardized protocols. The measurements were taken in accordance with the guidelines of the International Society for the Advancement of Kinanthropometry (ISAK).

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Endomorphy, mesomorphy, and ectomorphy scores were calculated using the Heath-Carter equations and determined with the somatocard system. These three numerical components were treated as continuous variables for subsequent statistical analyses.

2.2.2 Swimming motor skills assessement

The evaluation of basic motor skills was realized in a semi-Olympic indoor swimming pool (25 meter) at a constant temperature, according to the protocols proposed by G.Cazorla (1993).

- Buoyancy level

Test in vertical position in the water, the swimmer to be evaluated stands vertically in the water at a point where he has no foothold. At the evaluator's signal, he places his hands flat on the sides of his thighs, arms outstretched on either side of his body, lower limbs clenched. He then realizes a maximum inspiration followed by an apnea lasting 15 to 20 seconds. Once the subject has stabilized in a vertical position in the water, the level reached by the surface of the water is noted.

Head completely submerged	0
Hair	1
Forehead	2
Eyes	3
Nose	4
Mouth	5
Chin	6
Neck	7

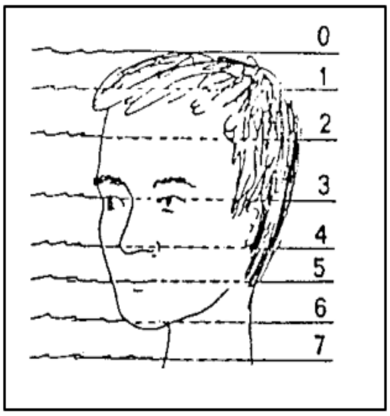

Figure 1. Illustration of the Buoyancy Level Test (Cazorla, 1993, p. 101).

- Front glide Length:

After a push-off from the wall of the pool, the subject realizes a front crawl glide as long as possible. Immediately before impulse, he inhales profoundly and realizes the test in apnea. The arms must be straight and close to the head at ear line. At the stop, measure the distance to the closest mellimeter between the feet and the edge of the pool.

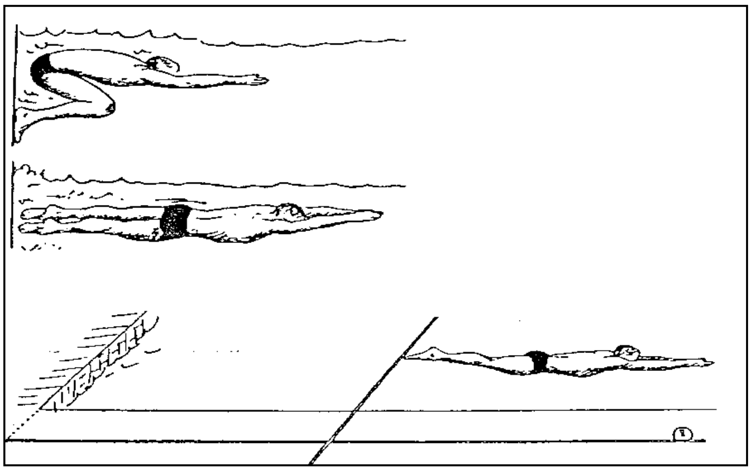

Figure 2. Illustration of the front glide Test (Cazorla, 1993, p. 105)

- Front glide length after start:

From the starting block, corresponding to the water line closest to one of the two edges of the pool, the subject makes a normal start, pushing to the maximum of his possibilities, and slide as far as

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possible, body in complete extension without moving. Record the greatest distance reached between the edge of the starting block and the subject's feet when this one are at a standstill.

- Propulsion efficiency

To assess propulsion efficiency, several authors (Chollet & al., 1997 ; Pelayo & al., 1997) utilize the swimming index (SI) based on the methodology of Costill (1985). This index is determined by the multiplication of swimming speed (S) and stroke length (SL), and is expressed in the following formula:

$SI = S \times SL$ (m^2/s/cycle)

- Swimming speed (S) : Students performed a 25-meter freestyle swim, starting in the water. performance was measured to the hundredth of a second using digital stopwatches, in a 25 m pool. The average swimming speed was then calculated as :

$$S = D \div T \text{ (m/s)}$$

- Stroke Rate (SR) The average Stroke Rate was assessed by timing (Ts) three swimming cycles during the central 15 meters. The time measured in seconds was then converted to cycles /minute through multiplication by 60 :

$SR = (3 \div Ts) \times 60$ (cycles / min).

- Stroke Lenght (SL) : According to (Salo & Riewald, 2008 ; Cholet, 1997) stroke lenght or distance per stroke can be derived from swimming speed, since speed is both the ratio of distance to time and the product of stroke lenght and stroke rate. The average (SL) was therefore calculated as.

$SL = S \div SR$ (m/cycle).

2.3. Data Reliability

All measurements were obtained using calibrated instruments. Prior to data collection, assessors received a briefing to standardize protocol adherence.The test-retest reliability analysis conducted on a subsample (n= 15) was analyzed using the Intraclass Correlation Coefficient (ICC) with a two-way mixed model. The results demonstrated moderate to good reliability, with values ranging from 0,74 to 0,81. These values confirm the stability of the anthropometric and hydrodynamic assessments.

Table 1. Intraclass Correlation Coefficients (ICC) for the test-retest measurements (n=15)

	ICC (3,1)	**Interpretation**
Somatotype	0,84	Good
Buoyancy level	0,76	Good
Front glide Length (m)	0,81	Good
Front glide length after start (m)	0,74	Moderate/Good
Swimming index (m^2/s/cycle)	0,78	Good

2.4. Statistical Analysis

Descriptive statistics, including means and standard deviation were calculated for all anthropometric and swimming variables.

A one-way ANOVA was performed to compare swimming motor skill scores across somatotype categories, and post-hoc Tukey’s HSD tests were conducted to identify spécific groups différences. The Pearson correlation was calculated to test the relationship between somatotype component

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scores (used separately as continuous independent variables) and swimming motor ability parameters. Statistical significance was set at p < 0,05.

2. Results

3.1 Descriptive Results

The results of the descriptive analysis, of Anthropométric variables are presented in table 02.

Table 2. Descriptive statistics mean and standard deviation of the anthropométric variable

Variable	Mean ± SD	Variable	Mean ± SD
Height (cm)	176 ± 0,06	Endomorphy	2,5 ± 0,9
Weight (kg)	72,14 ± 11,39	Mesomorphy	5,2 ± 1,1
Arm span (cm)	1,77 ± 0,06	Ectomorphy	3,1 ± 0,8

The results of the descriptive analysis, of swimming motor skills are presented in table 03.

Table 3. Descriptive statistics mean and standard deviation of the swimming motor skills variables

Variables	Mean ± SD
Buoyancy level	03,14 ± 1,11
Front glide (m)	4,67 ± 1,16
Front glide after start (m)	7,67 ± 2,03
Swimming index ($m^2 \cdot s^{-1} \cdot cycle^{-1}$)	0,93 ± 0,08

3.2.Comparative of swimming motor skills according somatotype groops

Analysis of variance (ANOVA) identified highly significant differences between somatotype groups for all motor skills in swimming (table 04).

Table 4. Comparison of swimming motor skills across somatotype groups (Mean ± SD) and ANOVA results.

Swimming motor skill	Mesomorph	Ectomorph	Endomorph	F (2,39)	P
Buoyancy level	3,49 ± 1,04^a	2,47 ± 0,94^b	4,02 ± 0,72^a	7,28	< 0,01
Front glide (m)	5,35 ± 0,99^a	4,23 ± 0,88^b	3,36 ± 1,00^b	10,00	< 0,001
Front glide after start (m)	9,29 ± 1,74^a	6,52 ± 1,17^b	5,16 ± 0,68^b	25,49	< 0,001
Swimming index ($m^2 \cdot s^{-1} \cdot cycle^{-1}$)	1,15 ± 0,15^a	0,84 ± 0,17^b	0,68 ± 0,12^c	24,00	< 0,001

Values are presented as mean ± SD. Different superscript letters (a,b,c) within the same row indicate sgnificant differences between somatotype groups (one-way ANOVA followed by Tukey post-hoc test, p <0,05).

On figure 3. we can see the comparative results of motor skills according to the different somatotypes (ectomorph, mesomorph, and endomorph)

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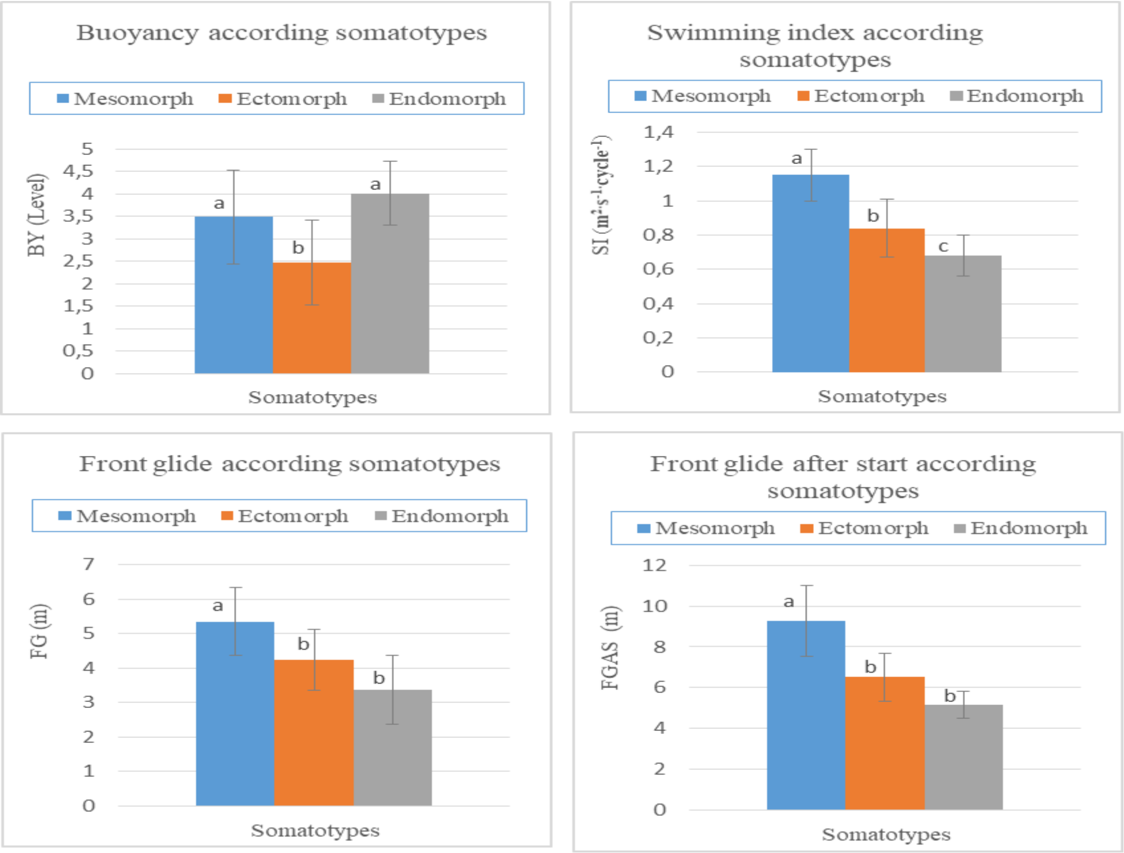

Figure 3. Swimming motor skills (Means ± SD) according to somatotypes.

BY *:Buoyancy -* ***FG*** *:Front glide -* ***FGAS*** *: Front glide after start -* ***SI*** *: Swimming Index*

Different letters above bars indicate significant differences between groups (one-way ANOVA followed by Tukey post-hoc test, p <0,05) Bars sharing the same letter are not significantly different. Significant differences in swimming motor skills were observed among three somatotype groups (table 3). Buoyancy level differed significantly between groups (F(2,39) = 7,28, p<0,01). Tukey's post-hoc analysis revealed that ectomorph students exhibited significantly lower buoyancy than mesomorph (p<0,01), whereas no significant difference was found between mesomorphs and endomorphs. Functionlly, endomorphic students acheived the highest levels, while ectomorphs showed the poorest buoyancy performance. Front glide distance showed a significant effect of somatotypes (F(2,39)= 10,00 , p<0,001). Mesomorph students achieved significantly greater glide distances than ectomorphs (p<0,01), with no significant difference between the latter two groups. A similar pattern was observed for front glide after the start (F(2,39)= 25,49, p<0,001), where mesomorphs demonstrated superior performance compared with ectomorphs and endomorphs. The swimming index, reflecting propulsion efficiency, differed significantly across somatotypes (F(2,39)= 24.00, p<0,001). Mesomorph students obtained the highest values, followed by ectomorphs, whereas endomorphs displayed the lowest propulsion efficiency. All pairwise comparisons were statistically significant, with mesomorphs outperforming ectomorphs and endomorphs (p<0,001), and ectomorphs also achieving higher values than endomorphs (p<0,01).

3.3 Relationship between somatotypes and swimming motor skills

The results of Pearson's correlations between somatotypes scores and swimming motor skills are presented in Figure 4.

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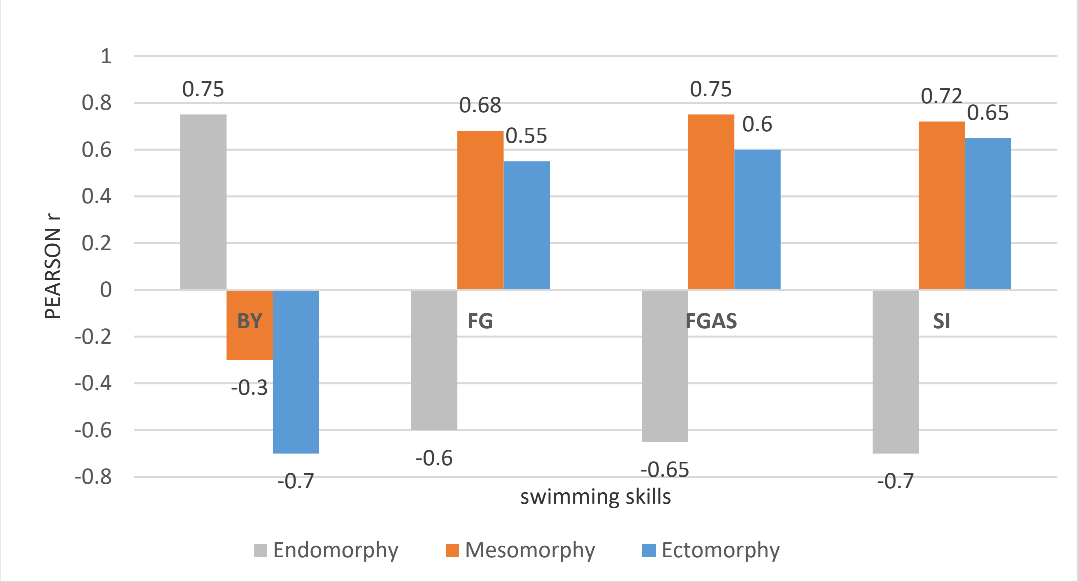

Figure 4. Correlation between somatotypes and swimming motor skills

In endomorphs, a positive correlation was observed with buoyancy but a negative one with front glide length and glide distance after start; and also with swimming index.

For mesomorphs, negative correlations were recorded with buoyancy (lower buoyancy), while strong positive correlations were noted with better gliding, longer starts, and more efficient propulsion (better swimming index).

Among ectomorphs, the results indicate negative correlations with buoyancy but positive correlations with better front glide and longer glide after start, as well as better propulsion efficiency, although less important compared to mesomorphs.

3. Discussion

The results highlighted significant differences in swimming parameters across somatotype groups, supporting and extending previous research regarding the influence of body morphology on aquatic motor skills. Pearson correlation results also provided nuanced evidence : mesomorphy was positively correlated with almost motor skills measures, except buoyancy, while endomorphy was exhibited in an opposite manner (positive association with buoyancy and negative one with propulsion efficiency), and The ectomorph shape increased speed due to its aerodynamic profile, at the detriment of reduced buoyancy.

Mesomorphic students proved better at buoyancy, glide distance and swimming efficiency, compared to endomorphic and ectomorphic. This is consistent with recent research revealing that mesomorphic athletes) demonstrate superior propulsive effectiveness and swimming economy. (Markovic & Milosevic, 2023 ; Rejman & al., 2023). The excellent muscular force generating capacity of mesomorphs provides favourable glide distance races but also for sprint swimming, in contrast, ectomorphic students that had less floaty and linear body form seemed to have relatively poor buoyancy and propulsion efficiency. This could be explained by a limited ability to produce propulsive power, as has been suggested in recent biomechanical studies (Siders & al., 1993 ; Zampagni, & al., 2008). The lower fat mass in ectomorphs might impose disadvantages on buoyancy, but advantages for streamlining, suggesting a more nuanced trade-off that requires deeper exploration.

Endomorphic individuals exhibited greater buoyancy, but inferior relative propulsion efficiency and longer swim times in accordance with previous findings where higher adiposity and fat mass values are associated with an increased passive drag but enhanced flotation. This morphology may constrain speed-specific skill acquisition during swimming learning, especially for aquatic skills acquired in later adolescence, when neural plasticity is more limited.The late introduction of swimming lessons among students in this study corresponds to the general practice in many schools considering physical education. Previous evidence also highlights that the most appropriate age for successful motor learning in swimming is early childhood, when neuroplastic and psychological factors which drive skill development are more feasible (Langendorfer & Bruya, 1995 ; Minkels & al., 2025). The variability found in motor performance of late learners in the current study emphasizes the need for personalization of intervention using a morphological based approach. A customized pedagogical approach that takes into account body composition, somatotype, and motor learning ability can increase teaching effectiveness, promote inclusive participation, and maximize potential health and performance benefits (Price & al., 2024). This study included only male students; future research should be conducted on more diverse samples (in terms of gender and expertise). Longitudinal models could also help to highlight the impact of these somatic differences on the development of swimming motor skills across time.

4. Conclusion,

Somatotype significantly affects the learning and performing of main swimming skills, in late-adolescents. Mesomorphs are favored, while endomorphs and ectomorphs have various advantages and disadvantages. The current findings support recent literature promoting the need for somatotype considerations in the area of learning and training, in order to facilitate the acquisition of motor skills in swimming. These results support targeted teaching strategies for the consideration and modification of specific morphologies that will enable all students, irrespective of somatype, to achieve success in swimming and make maximum gains from water-based experiences.

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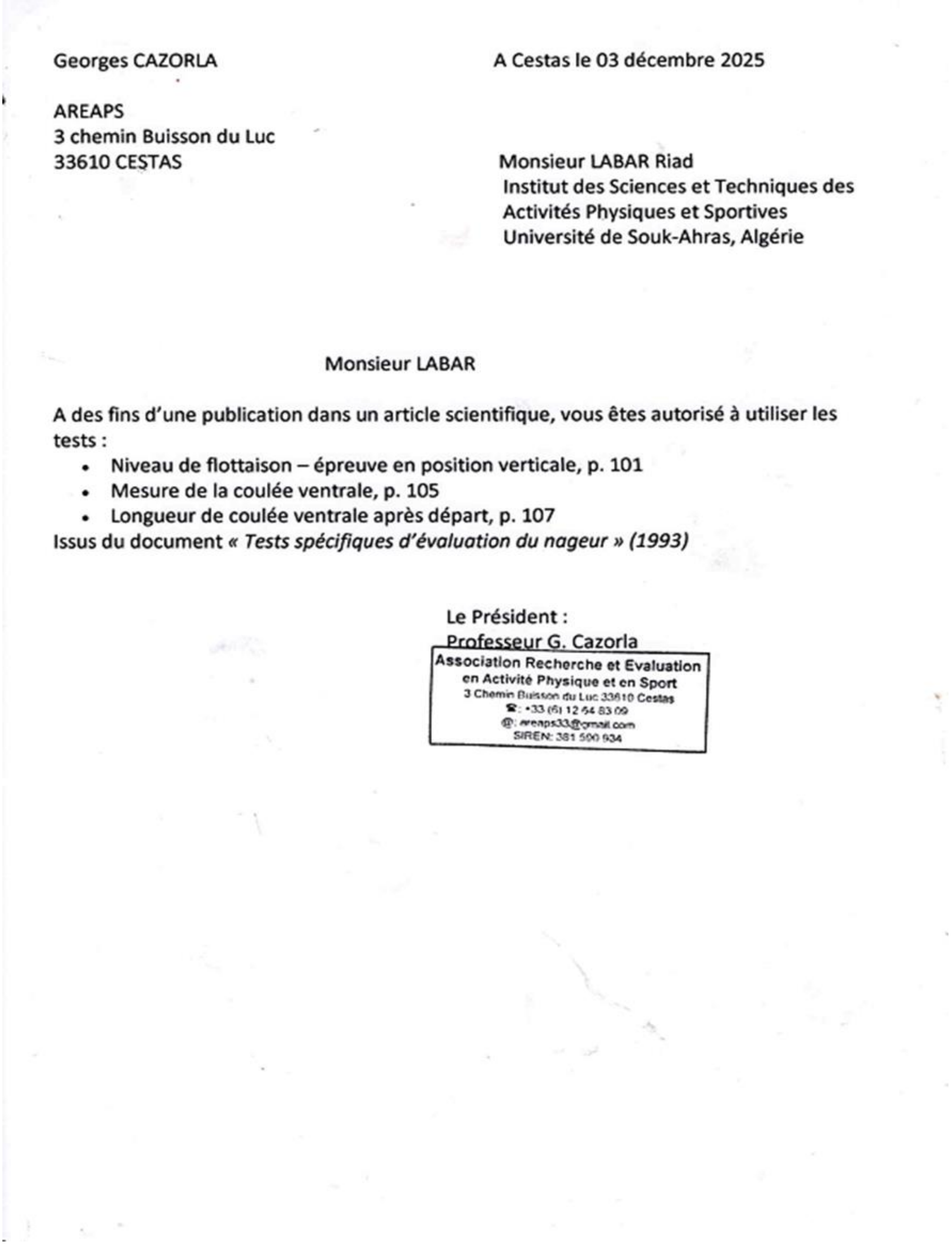
Appendix:



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Monsieur LABAR

A des fins d'une publication dans un article scientifique, vous êtes autorisé à utiliser les tests :

- Niveau de flottaison – épreuve en position verticale, p. 101
- Mesure de la coulée ventrale, p. 105
- Longueur de coulée ventrale après départ, p. 107

Issus du document *« Tests spécifiques d'évaluation du nageur » (1993)*

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