

## Exploring age-related psychophysiological patterns in bullying behaviors: An investigation of adolescent judokas

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### Abstract:

**Problem statement:** Adolescent bullying within the judo context is an area that has yet to be thoroughly investigated, despite its significant impact on the well-being of young athletes. Understanding age-specific patterns in bullying behaviors among judokas and elucidating psychophysiological factors that underlie these behaviors is crucial. This knowledge is indispensable for developing targeted and effective intervention strategies to address and mitigate the adverse effects of bullying in the judo community. **Approach:** This study adopted an integrative methodology, combining both physiological and psychological assessments. By concurrently examining heart rate variability (HRV) and conducting psychological evaluations, we aimed to unravel complex interconnections among autonomic regulation, self-esteem, aggressive tendencies, and the roles individuals play in bullying scenarios. Our investigation involved 82 adolescent judokas, segregated into two age groups: 6-11 years old (Group A) and 12-16 years old (Group B). **Purpose:** Our study delves into age-related patterns of bullying behaviors among adolescent judokas, concurrently aiming to unveil to intricate connections between physiological responses and psychological attributes. **Results:** We uncovered age-related variations in HRV parameters within our cohort of adolescent judokas. Notably, Group B, comprising older athletes, demonstrated significant increases in heart rate, stress index values, and low-frequency waves (LF), indicating heightened sympathetic modulation. Conversely, high-frequency waves (HF), reflective of parasympathetic activity, decreased with age. Our examination of bullying roles revealed that Group A had a stronger association with the "Viewer" role, while Group B showed a greater inclination towards the "Initiator" and "Protector" roles. Further investigation uncovered connections between bullying roles and psychophysiological traits. Initiators and their supporters exhibited lower heart rates (HR), suggestive of reduced physiological arousal, coupled with aggression and self-esteem. In contrast, "Protectors" displayed elevated self-esteem, possibly influenced by judo practice, emphasizing its potential to enhance self-esteem among adolescent judokas. "Victims" experienced heightened tension, expressing latent aggression through negative emotions, emphasizing the necessity for specialized support and intervention. On the other hand, "Viewers" exhibited increased HF and a negative correlation with overt aggressive behavior, shedding light on their distinct psychophysiological profile. **Conclusion:** In summary, our in-depth analysis unveiled age-related shifts in HRV parameters, indicating heightened sympathetic activity and reduced parasympathetic activity in older adolescent judo athletes. This shifts align with the maturation of the autonomic nervous system, potentially influenced by athletic performance. Our study emphasized the dynamic nature of adolescent identity formation within the framework of bullying roles. As adolescents evolve, they tend to assume more active roles, driven by a need of self-expression and authority. This inclination may be influenced by judo's ethical principles, promoting responsible and empathetic behavior. These findings underscore the intricate interplay between psychological traits, physiological responses, and bullying roles among adolescent judokas. This understanding lays the foundation for predictive models and targeted interventions aimed at cultivating empathetic and responsible behavior. By doing so, we aim foster safer and more inclusive experiences for adolescents in the judo community.

**Keywords:** Bullying Behaviors, Adolescent Judokas, HRV Measurement, Psychological Assessments, Self-Esteem, Cardiovascular Health.

### Introduction

In the rapidly evolving landscape of the modern world, characterized by swift technological advancements and sociocultural changes, the development of individuals, particularly during adolescence, is profoundly influenced. These transformations have not been without consequences, particularly during the crisis-ridden stage of adolescence. Among the myriad of potential negative consequences, bullying emerges as a critical issue warranting in-depth study. Bullying behaviors among adolescents have attracted increasing

attention in recent years due to their profound impact on the well-being and development of young individuals (Koh & Wang, 2017; Silva et al., 2012; Bibou-Nakou et al., 2012; Chu et al., 2019). The prevalence, types, and consequences of bullying are well-documented in the literature, highlighting the urgent need for a comprehensive understanding of these behaviors. Understanding the complex interplay involved in the creation, developmental dynamics, and age-related components of bullying behaviors is essential for formulating targeted strategies to prevent bullying in today's ever-changing society.

Adolescence, recognized as a dynamic phase, is marked by rapid physical, psychological, and social metamorphoses (Özdemir et al., 2016; Christie & Viner, 2005). It is a period when adolescents actively seek to establish their identities, assert their independence, and define themselves within the social fabric (Sznitman et al., 2019; Becht et al., 2016). These developmental shifts hold substantial sway over their behaviors, including their susceptibility to engage in bullying (Humphrey & Vaillancourt, 2020; Homel, 2013). Consequently, investigating age-related trends in bullying behaviors becomes an essential undertaking.

Adolescents, due to their stage of development, are particularly vulnerable to the detrimental effects of bullying. The repercussions of bullying during adolescence are far-reaching, encompassing psychological distress, social isolation (Chu et al., 2019), and the potential for enduring mental health issues (Sigurdson et al., 2015; Hysing et al., 2019). The multifaceted nature of bullying within this age group encompasses various forms, spanning physical, verbal, relational, and cyberbullying (Wang et al., 2009; Estévez et al., 2019). These manifestations of bullying transcend cultural and geographical boundaries, impacting adolescents in various settings, be it within educational institutions, communities, or even specific groups or activities they are involved in. Exploring these trends within the context of adolescent judokas reveals a unique opportunity. These young individuals make the transition from childhood to adolescence while immersed in the structured and disciplined realm of judo training, an environment deeply rooted in the values of respect and discipline. In this context, the philosophy and principles of judo, which emphasize discipline, respect, and morality, take on profound significance. Beyond its physical advantages, engaging in judo has been shown to exert a positive influence on the psychosocial well-being of adolescents. It offers a wealth of health benefits, as Woodward (2009) has noted.

Studies, such as those by Matsumoto and Konno (2005), have demonstrated that participants in judo tend to exhibit higher levels of well-being, life satisfaction, and overall quality of life compared to normative samples. Additionally, engaging in judo during adolescence can significantly contribute to the development of an adolescent's identity, self-esteem, and competence. This insight is supported by research conducted by Danish et al. (1990), Fejgin (1994), Kleiber & Kirshnit (1991), and Zaharopoulos & Hodge (1991).

Considering this context, judo's role in preventing bullying and reducing aggression among adolescents emerges as a topic of profound importance. This dual role of judo, fostering character development and promoting psychosocial well-being, forms a crucial aspect of our study on age-related trends in bullying behaviors among adolescent judokas.

The study of bullying behaviors necessitates a well-rounded, multidisciplinary approach that integrates findings from various disciplines, incorporates diverse theories and theoretical research models (Holt et al., 2017), and encompasses both physiological and psychological dimensions. Physiologically, HRV reflects the overall effect of autonomic regulation of blood circulation, while psychological assessments offer insights into participants' self-perception, self-esteem, and their roles within complex social dynamics. The correlation between physiological responses and psychological attributes in the context of bullying can unearth critical insights into the underpinnings of these behaviors.

While extensive research has examined bullying behaviors among adolescents, there remains a noticeable gap in the literature concerning the relationship between age, physiological responses, and psychological attributes in the specific context of adolescent judokas. This study seeks to bridge this gap by investigating how age-related trends influence bullying behaviors within the unique milieu of judo training.

This research holds significance on multiple fronts. Firstly, it contributes to the fields of psychology and sports science by offering a nuanced understanding of the physiological and psychological factors that underlie bullying behaviors among adolescents engaged in judo. Secondly, the findings have practical implications for anti-bullying interventions and judo training programs. They may inform strategies to create a safe and supportive environment for young athletes while promoting healthy self-esteem and constructive social dynamics.

**The purpose of this study** is to investigate age-related trends in bullying behaviors among adolescent judokas. Our focus is on examining the potential correlations between physiological responses, specifically measured through HRV, and various psychological attributes like self-esteem, self-perception, and roles within bullying dynamics.

## Material & methods

**Participants:** The study sample comprised a total of 82 male participants, all of whom were judokas associated with the "Zeytun" Judo Club. The participants were divided into two distinct age groups: 6-11 years old (referred to as Group A) and 12-16 years old (referred to as Group B). Group A consisted of 52 individuals, while Group B encompassed 30 individuals.

All participants in both age groups met the inclusion criteria, which consisted of the following conditions:

- Absence of Cardiovascular or Respiratory Diseases: Participants were required to have no known history of cardiovascular or respiratory disorders.
- No Medication Interference: Participants should not have been under the influence of medications that could potentially impact heart rate variability.
- Voluntary Participation: Participants needed to express a willingness to partake in the study.

In Group A, the average age of participants was calculated to be 9.1 years, with a standard deviation of 1.4 years. In Group B, the average age was 13.4 years, accompanied by a standard deviation of 1.1 years. These age divisions were purposefully chosen to facilitate a comprehensive analysis of bullying behaviors within the context of judo, as participants transitioned from childhood through adolescence.

Regarding judo training experience, participants in Group A exhibited an average training duration of 2.2 years, with a standard deviation of 1.4 years. Conversely, Group B participants showcased an average training period of 4.01 years, with a standard deviation of 2.3 years. This variation in training experience could be attributed to the differing age ranges within the two groups.

Ethical considerations were meticulously followed, and both participants and their parents or legal guardians provided informed consent in accordance with the guidelines of the institutional review board.

**Procedure:** The HRV measurements for all participants were performed in the morning, around a consistent time frame, at the Sport EMI Scientific Research Center of the Armenian State Institute of Physical Culture and Sport. Prior to conducting the measurements, participants received instructions to abstain from consuming stimulants like caffeine and to avoid engaging in vigorous physical activity for a minimum of 12 hours. The HRV recordings were taken while participants were in a seated resting position and lasted for a duration of 5 minutes. The psychological procedures were conducted following strict ethical protocols to ensure anonymity and confidentiality. Participants were assured of the confidentiality of their responses.

**Instruments and Measurements:** Cardiac variability assessment was carried out employing the Varikard 2.51 apparatus, a well-established system renowned for its HRV measurement capabilities. The apparatus features an input voltage span of 0.3 mV to 5 mV, with approximate deviations of  $\pm 14\%$  for stress estimation and  $\pm 10\%$  for temporal intervals.

The subsequent heart rate variability metrics were scrutinized throughout the study to gauge the athletes' physiological condition:

- SDNN (Standard Deviation of NN Intervals): SDNN is a statistical measure of heart rate variability (HRV) that quantifies the overall variability in the time intervals between successive normal heartbeats (NN intervals). It provides insights into the total autonomic regulation of heart rate.
- Coefficient of Variation (CV): CV is a normalized measure of HRV, calculated by dividing SDNN by the mean RR duration, multiplied by 100. It expresses HRV as a percentage of the mean RR interval and is used to assess variability relative to the average heart rate.
- Stress Index: The stress index reflects the level of stress or regulatory strain on the cardiovascular system. It can indicate the impact of sympathetic or central regulation on heart rate and is sensitive to changes in autonomic balance during stress.
- Centralization Index: The centralization index assesses the centralization of heart rate control. Higher values suggest a more centralized control of heart rate, possibly indicating increased sympathetic dominance or stress.
- Index of Activity of Regulatory Systems (IRSA): IRSA is an integrative indicator that evaluates the overall activity of regulatory systems affecting heart rate variability. It considers various HRV parameters to assess the adaptive potential of the organism.
- High-Frequency Power (HF): HF power represents the high-frequency components of HRV and is associated with parasympathetic (vagal) influence on heart rate. It reflects respiratory modulation of heart rate.
- Low-Frequency Power (LF): LF power characterizes the low-frequency components of HRV and is linked to sympathetic nervous activity and its effect on heart rate. It often reflects vasomotor control.
- Very Low-Frequency Power (VLF): VLF power represents very low-frequency HRV components influenced by humoral factors. It may indicate metabolic regulation and energy-deficient states.
- Total Power of Heart Rate Variability (TP): TP represents the overall power of HRV across all frequency ranges, including HF, LF, and VLF. It provides a comprehensive measure of the total variability in heart rate. (Baevsky & Chernikova, 2017)

In addition to the collection of physiological measurements, this study incorporated rigorous psychological testing methodologies, facilitating a comprehensive exploration of participants' experiences. Three distinct assessments were strategically employed to provide comprehensive insights into various facets of participants' behaviors and inclinations:

*Norkina's Bullying Structure Test:* E. Norkina's "Building Structure" test served as a tool for diagnosing the distinct roles participants assumed within the intricate landscape of bullying dynamics. These encompassed roles such as the initiator or bully, the victim, the supporter, the protector, and the viewer. The test, comprising 25 closed-ended questions, facilitated the quantification of each role's expressive magnitude.

*The Hand Test:* Employing hand images as projective stimuli, this widely-used technique explores action tendencies and inclinations toward aggressive behavior. Participants interpret a series of 10 hand images, providing insights into behavioral traits and underlying emotions.

*Dembo-Rubinshtein Self-Assessment Test:* Focusing on self-perception, this test evaluates participants' self-esteem levels and the extent of their personal claims or demands.

By integrating these psychological assessments with physiological data, the study achieves a comprehensive understanding of participants' experiences within the realm of their judo training, shedding light on the intricate relationship between physiological responses and psychological attributes

**Statistical Analysis:** The HRV data were collected using the Varicard 2.51 device, and the recorded data were subjected to preprocessing steps, including filtering and artifact removal, to ensure data quality. The relevant HRV parameters were then calculated from the cleaned data. The ISCIM6 software was utilized for HRV data analysis. Psychological data were analyzed using descriptive statistics, independent t-tests, ANOVA, and correlation analysis in SPSS to explore age group differences and relationships between variables with a significance level established at  $p < 0.05$ .

**Results**

The following section unveils the culmination of our empirical inquiry, where we present and interpret the findings derived from an exhaustive analysis of physiological and psychological parameters across distinct age groups. Statistical analysis was performed to compare the heart rate variability (HRV) parameters between the two research groups: 6-11 years old (referred to as Group A) and 12-16 years old (referred to as Group B). The mean values of various HRV parameters were computed for each group and presented in Table 1.

**Table 1.** HRV Parameter Comparison between Group A and Group B

HRV Parameter	Group	Mean	Std. Deviation	t	Sig. (2-tailed)
Heart rate	Group A	85.8269	9.84731	2.181	.032
	Group B	80.9000	9.85883		
Standard Deviation of Normal-to-Normal intervals	Group A	60.6135	34.64263	-.960	.340
	Group B	67.6500	26.62102		
Coefficient of Variation	Group A	8.3904	4.10973	-.696	.489
	Group B	8.9733	2.67168		
Stress Index	Group A	153.9615	161.50723	2.184	.032
	Group B	94.7667	83.65351		
Index of Centralization	Group A	9.5096	56.48884	.721	.473
	Group B	2.0567	1.08903		
IRSA	Group A	3.7692	1.51613	-.974	.333
	Group B	4.1333	1.81437		
NArr%	Group A	.7519	2.58279	1.295	.199
	Group B	.1333	.49294		
High Frequency	Group A	42.4288	15.05862	2.757	.007
	Group B	34.8933	9.65790		
Low Frequency	Group A	38.0577	11.55726	-2.893	.005
	Group B	44.6167	8.78514		
Very-low Frequency	Group A	19.5058	12.77544	-.375	.709
	Group B	20.4733	7.89426		
Total Power	Group A	4733.7308	11246.41952	.278	.782
	Group B	4148.9000	3156.10001		

The first table (Table 1) presents a comparative analysis of physiological and heart rate variability (HRV) parameters between Group A and Group B. Specifically, the mean and standard deviation of various parameters were examined for both groups, and independent t-tests were conducted to ascertain potential differences between the groups. The results reveal noteworthy findings in several parameters. The heart rate exhibited a statistically significant difference between the two groups ( $t = 2.181$ ,  $p = 0.032$ ), with Group A (Mean = 85.82, SD = 9.8) displaying a higher average heart rate compared to Group B (Mean = 80.90, SD = 9.85). Similarly, the Stress Index demonstrated a significant variance ( $t = 2.184$ ,  $p = 0.032$ ), indicating that Group A (Mean = 153.9, SD = 161.50) exhibited higher stress index values compared to Group B (Mean = 94.76, SD = 83.65). Furthermore, differences were observed in the frequency domain of HRV parameters. High Frequency (HF) displayed significant variation ( $t = 2.75$ ,  $p = 0.007$ ), indicating that Group A (Mean = 42.42, SD = 15.0) had higher HF values than Group B (Mean = 34.89, SD = 9.65). Conversely, Low Frequency (LF) also exhibited a significant difference ( $t = -2.893$ ,  $p = 0.005$ ), suggesting that Group A (Mean = 38.05, SD = 11.55) had lower LF values compared to Group B (Mean = 44.61, SD = 8.78). However, parameters such as Standard Deviation of Normal-to-Normal intervals, Coefficient of Variation, Index of Centralization, IRSA, NArr%, Very-low Frequency, and Total Power did not show significant differences between the two groups (all  $p >$

0.05). Overall, these results offer insights into the distinctive physiological and HRV profiles exhibited by Group A and Group B.

**Table 2.** Comparative Analysis of Bullying Roles Perception between Group A and Group B

	Group	Mean	Std. Deviation	t	Sig. (2-tailed)
Initiator	Group A	7.0000	2.42536	-2.385	.019
	Group B	8.3000	2.29166		
Supporter	Group A	4.2500	1.91869	1.1558	.123
	Group B	3.6000	1.63158		
Protector	Group A	11.5385	2.25320	-2.209	.030
	Group B	12.6333	1.99107		
Victim	Group A	4.4231	1.45987	-.605	.547
	Group B	4.6333	1.60781		
Viewer	Group A	4.3269	1.72321	2.884	.005
	Group B	3.2333	1.52414		

Table 2 presents a comparative analysis of the perception of bullying roles between Group A and Group B, based on the Norikna test results. The results of the analysis reveal distinctive patterns in the perception of various bullying roles within the context of the Norikna test. Notably, the "Initiator" role demonstrates a statistically significant difference between Group A (Mean = 7.00, SD = 2.43) and Group B (Mean = 8.30, SD = 2.29) ( $t = -2.385, p = 0.019$ ). This finding suggests that Group A perceives themselves as less inclined towards the "Initiator" role compared to Group B. Similarly, a significant difference emerges in the perception of the "Protector" role ( $t = -2.209, p = 0.030$ ), indicating that Group A (Mean = 11.54, SD = 2.25) perceives themselves as less likely to assume the "Protector" role in comparison to Group B (Mean = 12.63, SD = 1.99). In contrast, the perception of the "Viewer" role showcases a noteworthy disparity ( $t = 2.884, p = 0.005$ ). This discrepancy points towards Group A (Mean = 4.33, SD = 1.72) perceiving themselves as more aligned with the "Viewer" role than Group B (Mean = 3.23, SD = 1.52). However, the differences in perception of the "Supporter" and "Victim" roles do not reach statistical significance (both  $p > 0.05$ ), implying that both groups exhibit similar perceptions of these roles. These variations shed light on potential differences in self-identification within the context of bullying dynamics.

**Table 3.** Differences in Hand Test Parameters between Group A and Group B

	Group	Mean	Std. Deviation	t	Sig. (2-tailed)
Agg	Group A	16.9712	12.59607	.398	.692
	Group B	16.0000	9.32183		
Dir	Group A	4.9038	5.46741	1.202	.233
	Group B	3.6667	3.81317		
Aff	Group A	6.8750	8.17809	-1.231	.223
	Group B	9.0833	7.61360		
Com	Group A	20.0481	13.01856	-.297	.767
	Group B	20.8333	10.55228		
Dep	Group A	2.3077	3.49531	-.950	.348
	Group B	3.4167	5.81627		
F	Group A	4.6154	6.01030	1.066	.290
	Group B	3.3333	4.74947		
Ex	Group A	5.7692	7.11493	-.688	.495
	Group B	7.1667	9.73204		
Crip	Group A	1.2981	2.77817	-2.984	.005
	Group B	4.4167	5.32088		
Des	Group A	5.2404	5.84228	3.260	.002
	Group B	1.9167	3.39138		
Ten	Group A	3.0288	5.63029	.946	.347
	Group B	2.0833	3.41670		
Act	Group A	18.0288	14.60540	-.709	.481
	Group B	20.2500	13.10353		
Pas	Group A	1.7788	3.74874	-1.104	.275
	Group B	2.8333	4.39108		
Bass	Group A	.0962	.48546	1.428	.159
	Group B	.0000	.00000		
Fail	Group A	5.1923	8.96406	2.478	.015
	Group B	1.6667	3.79049		
<i>Tendency towards Open Aggressive Behavior</i>	Group A	-2.9423	9.25968	1.393	.168
	Group B	-5.4667	7.00607		
<i>Degree of Personality Maladjustment</i>	Group A	3.5769	3.48299	-.462	.645
	Group B	3.9333	3.15062		
<i>Tendency to Escape from Reality</i>	Group A	4.2115	3.87216	3.641	.000
	Group B	1.4333	2.04574		
<i>Presence of Psychopathology</i>	Group A	12.0000	8.24621	3.101	.003
	Group B	6.8000	5.29411		

Table 3 presents the results of the comparative analysis of Hand test parameters between Group A and Group B. Among the assessed parameters, significant differences were observed in the DES ( $p = 0.002$ ), CRIP ( $p=0.005$ ) and FAIL ( $p = 0.015$ ).

Regarding the "Tendency towards Open Aggressive Behavior," no statistically significant difference was observed between the two groups. Similarly, the "Degree of Personality Maladjustment" did not exhibit a significant variation between Group A and Group B. However, notable disparities emerged in the "Tendency to Escape from Reality," with Group A demonstrating a significantly higher mean score compared to Group B ( $t = 3.641$ ,  $p = .000$ ). Furthermore, the "Presence of Psychopathology" displayed statistically significant differences between the groups ( $t = 3.101$ ,  $p = .003$ ), where Group A exhibited higher scores than Group B. The differences in these specific psychological attributes warrant further investigation into potential underlying factors contributing to these distinctions.

**Table 4.** Comparative Analysis of Self-Esteem and Level of Claims using the Dembo-Rubinstein Test

	Group	Mean	Std. Deviation	t	Sig. (2-tailed)
Self-Esteem	Group A	69.01	20.679	-.043	.966
	Group B	69.19	11.686		
Level of Claims	Group A	89.18	13.372	1.516	.134
	Group B	84.83	10.731		

The analysis of the Dembo-Rubinstein test results, as presented in Table 4, offers valuable insights into the psychological dimensions of "Level of Claims" and "Self-Esteem" for both Group A and Group B participants. In terms of the "Level of Claims," Group A exhibited a mean score of 89.18 with a standard deviation of 13.372, while Group B displayed a mean score of 84.83 with a standard deviation of 10.731. The statistical comparison between the two groups did not reveal statistically significant differences, suggesting that the perceived levels of aspirations, as assessed by this dimension, were relatively comparable between the two groups. These scores fall within the range associated with a realistic level of aspirations, which is indicative of participants' ability to hold well-grounded expectations of their abilities.

Shifting focus to the " Self-Esteem", Group A achieved a mean score of 69.01 with a standard deviation of 20.679, while Group B attained a mean score of 69.19 with a standard deviation of 11.686. The analysis indicated no statistically significant distinctions between the two groups in terms of self-esteem levels. Both groups exhibited mean scores within a range associated with moderate to high self-esteem, reflecting a realistic and balanced self-assessment.

The correlation analysis revealed several significant associations among the examined variables. Specifically, a negative correlation was observed between Heart Rate (HR) and the Initiator role ( $r = -.241^*$ ,  $p = .029$ ), as well as between HR and the Supporter role ( $r = -.266^*$ ,  $p = .016$ ). These findings suggest that higher heart rates were linked to lower inclinations toward both the Initiator and Supporter roles.

Additionally, High-Frequency (HF) variability displayed a positive correlation with the Viewer role ( $r = .270^*$ ,  $p = .014$ ), while Very-Low Frequency (VLF) variability exhibited a negative correlation with tendencies toward Open Aggressive Behavior ( $r = -.218^*$ ,  $p = .049$ ). This indicates that individuals with greater HF variability were more likely to adopt the Viewer role, whereas higher VLF variability was associated with reduced tendencies toward Open Aggressive Behavior.

Furthermore, the Protector role exhibited significant correlations with other psychological aspects. A strong positive correlation was identified between the Protector role and Self-Esteem ( $r = .346^{**}$ ,  $p = .002$ ), as well as between the Protector role and the Level of Claims ( $r = .222^*$ ,  $p = .047$ ). Conversely, the Viewer role displayed a negative correlation with the Degree of Personality Maladjustment ( $r = -.249^*$ ,  $p = .024$ ). These relationships highlight the intricate interplay between these roles and the psychological attributes they represent. The analysis of variance (ANOVA) results provided insights into the relationships between various psychological attributes and specific roles within the context of the study. Notably, the role of Viewer exhibited statistically significant associations with several attributes. Specifically, significant differences were observed in the variables IRSA ( $F = 2.763$ ,  $p = .010$ ), High Frequency ( $F = 2.583$ ,  $p = .015$ ), Low Frequency ( $F = 2.581$ ,  $p = .015$ ), Aggression ( $F = 2.608$ ,  $p = .014$ ), Exhibitionism ( $F = 1.434$ ,  $p = .197$ ), Passive Impersonal Responses ( $F = 1.785$ ,  $p = .094$ ), and Tendency towards Open Aggressive Behavior ( $F = 1.672$ ,  $p = .120$ ). These results suggest that the Viewer role is associated with variations in these attributes, emphasizing the complex nature of this role in relation to the identified psychological factors.

Similarly, the Victim role demonstrated a significant relationship with the attribute of Tension ( $F = 2.390$ ,  $p = .029$ ), highlighting a potential connection between being a Victim and experiencing varying levels of tension. The Protector role revealed significant associations with Self-Esteem ( $F = 3.910$ ,  $p = .000$ ) and Level of Claims ( $F = 2.013$ ,  $p = .040$ ), indicating that individuals embodying the Protector role may experience differences in self-esteem and perceptions of the claims they make.

Regarding the Supporter role, statistically significant connections were found with Heart Rate ( $F = 2.526, p = .017$ ), Directive behavior (Dir) ( $F = 1.648, p = .126$ ), Communication ( $F = 2.141, p = .042$ ), Exhibitionism ( $F = 2.416, p = .023$ ), and Active Impersonal Responses (Act) ( $F = 2.361, p = .026$ ). These findings suggest that the Supporter role is associated with variations in physiological and behavioral attributes, underlining its complex nature in relation to these factors.

In the context of the Initiator role, the ANOVA results indicated that Aggression ( $F = 1.733, p = .084$ ) and Self-Esteem ( $F = 1.591, p = .121$ ) showed some level of association with this role.

## Discussion

**Physiological Insights from HRV Data:** The analysis of heart rate variability (HRV) parameters in this study provides valuable physiological insights into the autonomic nervous system activity among adolescent judo athletes. These insights shed light on the intricate balance between sympathetic and parasympathetic modulation and their implications for sports performance and training.

One of the notable findings is the significant age-related variation in HRV parameters. Specifically, heart rate, the stress index, and low-frequency waves (LF) exhibit significant increases with age, while high-frequency waves (HF), indicative of parasympathetic activity, show a significant decrease. These age-related shifts in HRV parameters are consistent with the well-documented changes in autonomic nervous system function during growth and development.

During adolescence, the autonomic nervous system undergoes considerable adjustments. These changes are closely linked to hormonal fluctuations, physical maturation, and psychosocial factors. The observed increase in heart rate with age aligns with the general trend of decreasing vagal tone and increasing sympathetic influence seen during the teenage years. This physiological shift can be attributed to the maturation of the sympathetic nervous system, which becomes more responsive to stressors and physical demands as adolescents' progress through puberty. Consequently, older adolescent judo athletes may experience heightened sympathetic activity, reflected in their elevated heart rates.

The stress index, a parameter indicative of overall stress levels, also demonstrates an age-related increase. The decrease in high-frequency waves (HF), a marker of parasympathetic activity, with age is consistent with the broader literature on autonomic development. Parasympathetic tone tends to decrease during adolescence, partially due to the increased influence of sympathetic activity. This shift is related to the maturation of the autonomic nervous system, as well as the psychological challenges and emotional changes that adolescents commonly experience. The reduced parasympathetic activity in older athletes suggests a shift towards sympathetic dominance, which may have implications for their response to physical and psychological stressors. Moreover, this shift may be influenced by athletic performance, as delineated by Stepanyan & Lalayan (2023). Their research revealed that athletes lacking significant athletic accomplishments exhibited higher parasympathetic activity and vasomotor center activation when juxtaposed with their high-level athlete counterparts.

Interestingly, the age-related changes in HRV parameters align with research linking high parasympathetic activity (reflected in higher HF values) to enhanced athletic performance. This association suggests that younger athletes, characterized by higher parasympathetic activity, may exhibit superior athletic performance compared to their older counterparts. This finding supports previous research by Cayres et al., which demonstrated a positive relationship between sports practice and autonomic parasympathetic nervous system activity in adolescents, and research by Stepanyan et al. (2023), according to which the high-frequency (HF) component has been found to impact the performance of adolescent judokas. It implies that as athletes gain more sports experience and efficiency with age, there may be a concurrent decrease in parasympathetic activity and an increase in sympathetic dominance, facilitating the physiological mobilization required for judo performance.

The elevated levels of low-frequency waves (LF) observed in the study indicate enhanced sympathetic modulation and regulation of vascular tone among adolescent judo athletes, particularly in older participants. This heightened sympathetic activity can be attributed to the physical and psychological demands of the sport, as well as the competitive nature of judo training and competition. These findings align with prior research by Bae et al. (2020), which identified a dominance of sympathetic nervous activity in high-performance athletes, signifying higher levels of overtraining and competition stress compared to low-performance athletes.

The interaction between age-related changes in HRV and sports practice further highlights the complexity of autonomic regulation in adolescent athletes. While advancing age is generally associated with decreased vagal response and HRV, the regular physical exercise characteristic of sports practice can have a modulating effect. Exercise has the potential to attenuate the reduction in parasympathetic activity, preserving a more balanced autonomic nervous system profile in adolescent athletes.

In conclusion, the analysis of HRV parameters provides valuable insights into the physiological adaptations of adolescent judo athletes. The age-related shifts in HRV parameters, characterized by increased sympathetic activity and decreased parasympathetic activity, underscore the dynamic nature of autonomic nervous system regulation during growth and development. These findings also suggest that judo athletes may

undergo specific physiological adaptations to meet the demands of their sport, including enhanced sympathetic modulation to handle the physical and mental challenges of training and competition.

**Perception of Bullying Roles:** Developmental dynamics exert a profound influence on how adolescents perceive and engage with bullying roles. Adolescence, a phase marked by significant physical, emotional, and social changes, serves as a crucible for evolving attitudes and behaviors related to bullying roles. This transformation is most evident in three primary bullying roles: the aggressor or initiator, the defender or protector, and the viewer. According to our research data, these roles undergo significant changes with age, offering invaluable insights into the complex process of identity formation during adolescence.

Adolescence, characterized by profound self-discovery and the quest for a distinct identity, often leads to notable shifts in attitudes and behaviors, particularly in the realm of bullying roles. One compelling explanation for these changes lies in the very nature of identity development. Adolescents, in their pursuit of self-definition and their roles within social networks, naturally gravitate toward more active roles, such as the aggressor or protector, as underscored by our data. These roles provide avenues for self-expression, the assertion of authority, and the exploration of personal values and boundaries.

Conversely, the passive role of the viewer, characterized by detachment and non-participation, loses its appeal as adolescents increasingly seek active engagement in social interactions. Therefore, the observed transformations in bullying roles can be seen as reflections of the intricate interplay between identity formation and social behavior during the tumultuous teenage years.

Furthermore, it's worth highlighting the impact of judo and its underlying philosophical principles on identity formation and the selection of bullying roles. Judo transcends being merely a physical sport; it is a discipline that instills values such as respect, discipline, and responsible use of strength. These values deeply resonate with judo practitioners, especially adolescents. The philosophy of judo places great emphasis on mutual welfare and benefit, promoting empathy, self-control, and the responsible exercise of power. Adolescents engaged in judo may internalize these principles, influencing their perception and enactment of bullying roles.

For instance, those with a background in judo may be more inclined to take on the role of a protector or defender due to their heightened sense of responsibility and empathy. They may feel a moral duty to shield their peers from harm, aligning with judo's philosophy of mutual welfare. Conversely, the tenets of judo might deter them from adopting the role of an aggressor, as the sport encourages the controlled and disciplined use of strength rather than aggression. Additionally, judo practitioners may be less likely to assume the passive role of a spectator, as the sport emphasizes active participation and engagement.

In this context, the influence of judo on identity formation emerges as a positive factor contributing to the cultivation of responsible and empathetic behavior among adolescents, potentially leading to a reduction in the prevalence of bullying roles. The research conducted by Batista and Delgado (2013) provides further credence to this notion. Their study reveals that engaging in judo practice positively affects the formation of self-concept and self-esteem among adolescents. Additionally, it demonstrates improvements in school performance associated with judo participation. These findings underscore the multifaceted benefits of judo, suggesting that it not only fosters physical fitness but also nurtures essential psychological attributes that can empower adolescents to make constructive choices in their social interactions. However, as the impact of judo on bullying roles warrants a more comprehensive exploration, further research is essential to elucidate the extent and nuances of this influence, with potential implications for anti-bullying interventions in judo and other sports characterized by strong ethical foundations.

**Tendencies toward Aggressive Behavior:** The results of the Hand Test, a measure designed to assess action tendencies and inclinations towards aggressive behavior, provide intriguing insights into the developmental trajectory of adolescents' responses. Specifically, two key parameters, "Fail" (indicating the number of unanswered questions) and "Des" (description), exhibit significant shifts with increasing age. As adolescents progress through their formative years, they appear to move away from passive responses, signifying a decrease in unanswered questions. This transition reflects a growing inclination towards active engagement, not only in test-taking but also in their broader social roles. It suggests a heightened self-identity and an evolving sense of agency as they navigate the complexities of adolescence.

The Hand Test also reveals an increase in "Crip" (crippled) tendencies within the older age group. This shift may be attributed, in part, to the competitive experiences of older judokas. With increasing age, judo practitioners tend to accumulate more time in the sport, which can lead to a higher likelihood of sustaining injuries. These injuries, although physical in nature, can also impact psychological responses, manifesting as heightened "Crippled" tendencies on the Hand Test.

A notable finding in the Hand Test results is the significant decrease in the "Tendency to Escape from Reality" and the "Presence of Psychopathology" with increasing age. This decline can be seen as a consequence of development and age-related features. As adolescents mature and progress through adolescence, they typically undergo significant psychological growth. They become better equipped to cope with the challenges of reality, and their psychopathological tendencies may diminish as they develop more adaptive coping strategies. This decrease in escapism and psychopathology underscores the transformative power of age and development in shaping adolescents' psychological responses, potentially contributing to improved mental well-being and resilience.



**Psychophysiological Profiling of Bullying Roles among Teenage Judokas:** Our investigation into the psychophysiological profiles of bullying roles among teenage judokas has unveiled a multifaceted tapestry of findings, offering profound insights into the intricate interplay of psychology and physiology within this unique context.

Our examination of the Initiator role within the context of bullying roles uncovered intriguing associations, particularly with Aggression and Self-Esteem. This finding aligns with research by Glazman (2009), shedding light on the distinct psychological features and behaviors often exhibited by those who assume the role of aggressors or initiators. As adolescents take on the Initiator role, they become more assertive, utilizing their growing confidence to actively intimidate their peers. Moreover, frequently display authoritarian tendencies. These tendencies are instrumental in their efforts to establish dominance over their "supporters" and provide a rationale for their bullying actions. Additionally, it's worth noting that the relationship between self-esteem and the role of the aggressor has been observed in prior studies. Zhong et al. (2021) found that self-esteem played an important mediating role in the relation between bullying victimization and depressive symptoms, providing further insights into the multifaceted nature of this role.

Conversely, adolescents inhabiting the Supporter role present a complex profile characterized by an amalgamation of authority and dependence. Despite typically occupying a low sociometric status, supporters often wield significant degrees of authoritarianism, resulting in internal dissonance. This active aggression correlates with specific psychological aspects, notably directive behavior.

Additionally, our study identified a strong correlation between the Initiator and Supporter roles and a decrease in heart rate (HR). This physiological response suggests that the active and aggressive behaviors characteristic of initiators and their supporters may contribute to a reduction in heart rate, emphasizing that overt actions in this context lead to decreased sympathetic activity, thereby influencing a decrease in heart rate.

In contrast, adolescents adopting the Protector role manifest distinctive characteristics, characterized by high sociometric status and satisfaction derived from social interactions. These individuals exude self-esteem, particularly concerning qualities such as reliability and understanding, and prioritize kindness as a core value. Our research underscores that self-esteem and the level of claims play pivotal roles in shaping the Protector role. Furthermore, it reveals that the practice of judo, with its emphasis on respect, discipline, and the responsible use of strength, can serve as a catalyst for enhancing self-esteem. This finding suggests that judo may play a pivotal role in reinforcing the Protector role among adolescent judokas.

Viewers, also referred to as neutral participants, occupy a unique position within the bullying dynamic. Viewers exhibit high levels of tolerance, albeit with discerning standards for the quality of tolerance they practice. Our findings emphasize the passive yet influential role that viewers play in sustaining the bullying cycle. Additionally, our research reveals a correlation between the Viewer role and parasympathetic activity, indicating their passive engagement in bullying dynamics. Furthermore, there is a negative correlation between the Viewer role and open aggressive behavior, underscoring their distinctive position within the bullying paradigm.

In contrast, the Victim role stands in stark contrast, characterized by the internal tension resulting from the absence of overt aggressive behavior. This role often harbors a complex emotional profile, as evidenced by Stepanyan et al.'s (2022) research, which uncovered a multitude of negative emotions such as anxiety, frustration, latent aggression, and a general sense of negativity. The identified connection between the Victim role and this underlying tension serves as compelling evidence of the presence of latent aggression as a defining characteristic of this role. This latent aggression, concealed beneath the surface, can have lasting effects on the emotional well-being of those who occupy this role, highlighting the critical need for support and intervention to address the complex experiences of victims in the context of bullying dynamics.

In summary, our study provides an exhaustive understanding of the psychophysiological profiles of bullying roles among teenage judokas. It elucidates the intricate relationship between psychological traits, physiological responses, and the dynamics of bullying roles. Moreover, it underscores the potential of judo as a means to elevate self-esteem and influence the choice of bullying roles among adolescents. This comprehensive knowledge serves as a foundation for targeted interventions and support systems aimed at promoting empathetic and responsible behavior among adolescents, ultimately fostering safer and more inclusive adolescent experiences.

**Limitations:** In the pursuit of knowledge and understanding, it's crucial to recognize the boundaries that frame our research. Firstly, our sample size, although carefully selected, consists exclusively of teenage judo athletes, a rather specific demographic. Consequently, while our results provide profound insights into this unique population, they may not seamlessly extrapolate to broader adolescent groups. Moreover, the cross-sectional design of our study, while valuable in its own right, restricts us from asserting causation definitively. Longitudinal research would be necessary to truly grasp the evolution of psychophysiological profiles over time, teasing out causal threads from the intricate tapestry of adolescence.

Our study also leaned on self-report measures, a common methodology with its own set of potential biases. Participants' responses, especially in sensitive areas like bullying roles and emotional states, may have been influenced by social desirability bias. While we took steps to foster an environment of trust and confidentiality, the nature of self-reporting remains inherently subjective. Furthermore, our exploration centered

largely on the influence of judo on psychophysiological responses, but it did not delve into the possible impact of varying training styles, coaching approaches, or competitive levels within the sport. These nuanced factors, inherent to the judo experience, could have nuances that merit further investigation.

### Conclusions

In summary, our comprehensive analysis has yielded several noteworthy conclusions. Firstly, our investigation into heart rate variability (HRV) parameters has uncovered age-related shifts, indicating increased sympathetic activity and decreased parasympathetic activity in older adolescent judo athletes. These findings are consistent with the maturation of the autonomic nervous system during adolescence and may be influenced by athletic performance. Secondly, our study of bullying roles highlights the dynamic nature of identity formation during adolescence, with adolescents gravitating towards more active roles as they seek self-expression and authority. Judo's ethical principles appear to shape these choices, promoting responsible and empathetic behavior, potentially reducing the prevalence of bullying roles among judo practitioners.

Additionally, initiators and supporters display heightened aggression and self-esteem, with a notable decrease in heart rate (HR) associated with their active and aggressive behaviors. In contrast, Protectors exhibit elevated self-esteem, often influenced by judo practice, underscoring its potential to enhance self-esteem among adolescent judokas. Viewers, on the other hand, maintain a neutral yet influential role, characterized by passive engagement and parasympathetic activity, setting them apart within the bullying dynamics. Furthermore, Victims experience latent aggression in the form of tension, which manifests through negative emotions, highlighting the need for specialized support and intervention.

These findings collectively emphasize the intricate relationship between psychological traits, physiological responses, and bullying roles among adolescent judokas. Understanding this interplay provides a foundation for predictive models and targeted interventions to promote empathetic and responsible behavior, ultimately contributing to safer and more inclusive adolescent experiences. Future research should further explore the nuanced influence of judo on bullying roles, investigate additional psychophysiological correlates, and develop comprehensive strategies for bullying prevention within sports like judo that emphasize ethical values.

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**Conflicts of interest** - The authors declare no potential conflict of interest.

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