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Original article

Initial Study on Normative Data for Hand Grip Strength and Explosive Strength in Lebanese Population

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Abstract

The primary aim of this study is to define the norms as initial standards for handgrip strength for the Lebanese population. The secondary aim is to make a comparative analysis of these values with other available data. The study involved 303 healthy adults (179 males and 124 females) who represented diverse educational and training backgrounds across different regions of Lebanon. Participants' height and weight were assessed. Grip strength was measured for both dominant and non-dominant hand using a standardized handgrip strength protocol. Handgrip strength values were presented as absolute and relative (i.e., normalized to body mass) values. The analysis indicates that the summarized maximal force from both hands (F_{max}_SUM) and summarized rate of force development (RFD_{max}_SUM) in males and females align closely with international findings, within ±1 standard deviation. Compared to international standards, Lebanese handgrip strength values differ by 2.14% for males and 3.32% for females. However, more significant disparities are observed in explosive strength, with differences of 13.44% for males and 22.81% for females. Significant between-sex difference could be observed in F_{max}_SUM (45.35%) and RFD_{max}_SUM (48.75%), with males showing higher values than females.

Keywords: Gender Dimorphism, Muscle Force, Rate of Force Development, Normative Data

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Introduction

Across the epochs of human history, the hand has remained an anatomical phenomenon, essential for executing a diverse range of occupational tasks requiring precise coordination of hand-arm movements (Dogu et al., 2014). These activities, extending from fundamental actions such as dressing and grooming to complex professional duties, underscore the indispensability of the hand in facilitating human pursuits (Dopsaj et al., 2022). Furthermore, hands are regarded as multifaceted organs capable of facilitating intricate and precise interactions with the surrounding environment (Sobinov & Bensmaia, 2021). Hand health provides valuable insights into overall well-being, with vascular, musculoskeletal, and dermatological indicators offering diagnostic clues for various systemic conditions. Thus, the hand can serve as a crucial diagnostic window into the complex relationship between health and disease.

Throughout various activities, hands generate adequate strength by exerting the appropriate muscle force for gripping, a phenomenon referred to as muscle strength. This term is defined as the capacity of an individual muscle or a collective group of muscles to generate force during contraction against an external resistance (Dopsaj et al., 2019). The most frequently investigated mechanical characteristics of isometric muscle strength consist of maximal isometric force (F_{max}) and maximal isometric rate of force development (RFD_{max}). These two parameters can be effectively assessed using the maximal handgrip strength test (HGS), providing valuable insights into an individual's general strength capacity (Dopsaj et al., 2018; Dopsaj et al., 2022).

Also, HGS is a quick and practical method for identifying individuals with muscle weakness or those prone to various health issues like chronic diseases, cognitive decline, extended hospital stays, and mortality (Kocher et al., 2019). It should be noted that HGS is significantly influenced by age, gender, body size, as well as nutritional status, lifestyle, and occupation (Lam et al., 2016). Studies have shown that a weak grip is linked to a higher risk of mortality from cardiovascular disease and cancer, even after considering muscle mass and body mass index (Massy-Westropp et al., 2011). Assessing handgrip strength is a useful way to evaluate muscle function and quality of life, indicating not only hand muscle strength but also associations with strength in other body muscles as an indicator of overall body muscle strength (Miller et al., 1993; Salama et al., 2023). Strong hand grip strength is associated with healthy bone density, leading to suggestions of using it as a screening tool for osteoporosis and sarcopenia (Massy-Westropp et al., 2011; Saraiva et al., 2021).

Generally, the absence of normative handgrip strength data in Lebanon poses a challenge for healthcare providers and fitness professionals in accurately evaluating and guiding individuals. Multiple studies stress the importance of having population-specific normative data for handgrip strength, highlighting the need to tailor such data based on demographic, lifestyle, and ethnic factors (Leyk et al., 2007; Wang et al., 2018; Kocher et al., 2019; Alrashdan et al., 2021; Andraos et al., 2024. Therefore, the primary aim of this study was to define the initial standards for handgrip strength for the Lebanese population filling a gap in existing data for this demographic. The secondary aim is and to compare those norms to those in other countries and to international standards.

Methods

Design and participants

A diverse cohort of 303 healthy adult participants comprising 179 males and 124 females from various training backgrounds and regions across Lebanon were recruited for this study. All participants gave written consent following approval from the Antonine University Ethical Committee under the code 413 reference number 1675-2023, with specific requirements such as being free from limb injuries and hormonal disorders, abstaining from vigorous physical activity 48 hours prior to testing, and fasting for a minimum of 1.5 hours to maintain test validity and reliability. The research was conducted according to the Declaration of Helsinki (Christie, 2000). Basic characteristics of the sample are shown in Table 1.

Table 1. Descriptive data related to body composition characteristics according to gender

Variables	Mean	SD	CV %	SEM	Min	Max
Males						
Age (yrs.)	30.6	14.13	45.48	1.05	18.0	81.0
BH (cm)	176.8	7.2	4.06	0.53	158.0	200.0
BM(Kg)	81.4	14.6	18.02	1.09	53.6	145.3
BMI (kg/m$^{2)}$	25.98	4.04	15.38	0.3	16.9	42.5
BFM (Kg)	16.7	9.4	55.29	0.7	2.8	73.3
SMM (Kg)	34.0	9.2	27.05	0.69	23.52	58.2
PSMM (%)	44.12	6.27	14.31	0.47	24.8	59.9
PBF (%)	20.38	7.92	39.50	0.6	3.3	51.8
Females						
Age (years)	31.2	14.3	46.12	1.28	18.0	73.0
BH (cm)	163.3	6.3	3.86	0.56	149.0	183.0
BM(Kg)	63.8	12.29	19.21	1.1	39.4	113.4
BMI (kg/m$^{2)}$	24.01	4.58	19.16	0.41	16	39.7
BFM (Kg)	21.1	9.9	47.14	0.88	6.6	57.2
SMM (Kg)	20.2	6.0	30.00	0.53	11.0	33.0
PSMM (%)	32.87	6.19	18.78	0.56	20.8	50.0
PBF (%)	32.67	8.82	26.66	0.8	13.6	50.4

Measurement procedures

Anthropometrics

Physical assessments were carried out at the university's Laboratory of the 3S: Sport, Santé, Société (L3S), following standardized procedures. A qualified nutritionist conducted the physical measures, which included weight (BM), height (BH), body mass index (BMI), body fat mass (BFM), skeletal muscle mass (SMM), percentage in body fat mass (PBF), and percentage in skeletal muscle mass (PSMM) (Dopsaj et al., 2020; Rakić et al., 2022; Andraos et al., 2024). For body composition and anthropometric characteristics all measurements were made with bioelectrical impedance analysis (BIA, i30, Mediana, Korea), and a portable digital height scale (Campry, China) was used.

Handgrip strength test

The handgrip isometric test protocol was implemented following standardized procedures and using standardized handgrip device (Sports Medical Solution, Belgrade, Serbia). Subjects were seated upright in a chair, with one arm extended and holding the device, as described in previous literature (Dopsaj et al., 2019; Dopsaj et al., 2022). Previous studies have demonstrated high reliability of this handgrip test, with intraclass correlation coefficients between 0.938 and 0.977 for F_{max} and 0.903 to 0.971 for RFD_{max} (Marković et al., 2018). Prior to the test, participants received verbal instructions and performed two practice measurements with each hand. The test required exerting maximum pressure on the device for at least 2 seconds upon a signal, with verbal encouragement provided. Both dominant and non-dominant handgrip tests were conducted twice in random order, separated by a 1-minute interval of rest. During testing, participants were instructed to keep their arms by their side, with the tested arm slightly abducted from the body. F_{max} and RFD_{max} values were recorded using a laptop computer, with F_{max} representing the maximum muscle force achieved and RFD_{max} calculated as the maximum slope of the force-time curve. The onset of contraction was determined when the force-time curve's first derivative exceeded the baseline by 3% of its maximal value. The strain gauge used for testing was connected to a force reader with a precision of ± 0.1 N, and data were sampled at 500 Hz and filtered before calculating RFD_{max}. Data collection and processing were carried out using a software-hardware system designed for isometric measurements (Sports Medical Solutions Isometrics, ver. 3.4.0).

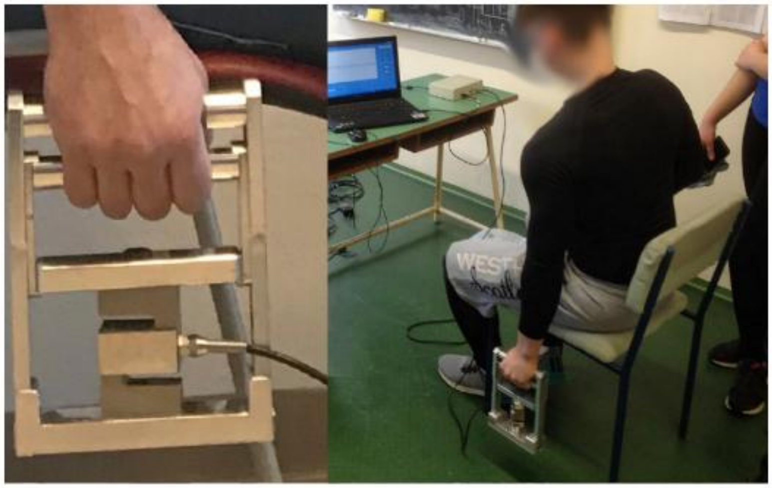

Figure 1. Photo showing the handgrip test position

Handgrip strength test

This study utilized a range of anthropo-morphology and performance variables to comprehensively analyze handgrip strength and explosive strength among the Lebanese population. The variables included age, gender, and several body composition metrics, such as Body Mass Index (BMI), Body Fat Mass (BFM), Skeletal Muscle Mass (SMM), Percent Skeletal Muscle Mass (PSMM), and Percent Body Fat (PBF). Performance variables were - Maximal Force (F_{max}) and Rate of Force Development (RFD_{max}) were recorded to assess the peak force and the speed of force generation during handgrip exercises, respectively, as a performance variables of handgrip strength and explosive strength. Additionally, relative measures such as Relative Force (F_{rel}) and relative Rate of Force Development (RFD_{rel}) were calculated to account for differences in body weight among participants, offering a more standardized comparison of muscular strength.

Statistical analyses

Descriptive statistics, such as the mean (Mean), standard deviation (SD), minimal and maximal measured value (MIN, MAX), coefficient of variation (CV%), the standard error of measurement (SEM) and its percentage relative to the mean (SEM%) were calculated for all variables to assess the precision and reliability of the measurements, and to provide indicators of central tendency and the dispersion of original data. To establish significant ranges for the data under examination, a 95% confidence interval for the mean was determined, including lower and upper bound reference lines. Normative values were derived utilizing two distinct metrological procedures methodologies: the calculation of seven classes' normative standard (7D - Very poor, Poor, Below standards, Standards, Above standards, Excellent and Superior) and the utilization of percentile distribution criteria (2.5, 5, 10, 30, 50, 70, 90, 95, 97.5 percentiles), according to Zatsiorsky (1982). Additionally, a MANOVA (Multivariate Analysis of Variance) was conducted to compare the all explored force (F_{max}_Sum) and rate of force development variables (RFD_{max}_Sum) between male and female participants, as a gender dimorphism data in absolute and relative values. To evaluate Lebanon's alignment with international standards for handgrip parameters related to maximal force (F_{max}_SUM) and rate of force (RFD_{max}_SUM) development across both genders, we compared the mean and standard deviation from previous studies on different populations. Lebanon's values were analyzed for agreement within the range of -1 to +1 standard deviation. Statistical analyses were carried out utilizing the software packages SPSS Win Statistics 26.0 and Excel 2016.

Results

Table 2 summarizes the descriptive results for key handgrip strength parameters by gender. The coefficient of variation (CV%) and standard error of measurement (SEM) indicate the consistency and precision of these measurements for both genders.

The handgrip test outcomes, acquired using a measuring tool, reveal minimal absolute measurement discrepancies. In males, discrepancies for F_{max} and RFD_{max} in both absolute and relative terms were 1.53% and 20.4%, respectively, while for females, the discrepancies were 2.38% and 26.45%.

Table 2. Descriptive statistics

Variables	Mean	SD	CV%	SEM	95% CI lower bound	95% CI upper bound	Min	Max
Males								
F_{max}_SUM (N)	957	180	18.8	1.41	931	984	494	1690
RFD_{max}_SUM (N/s)	5800	1324	22.8	1.71	5605	5996	1638	11457
F_{rel}_SUM (N/kg)	11.92	2.13	17.9	1.33	11.61	12.24	6.93	17.90
RFD_{rel}_SUM (N/s/kg)	72.34	16.08	22.2	1.66	69.97	74.49	22.97	111
Females								
F_{max}_SUM (N)	523	107	20.5	1.84	504	542	254	823
RFD_{max}_SUM (N/s)	2972	914	30.7	2.76	2810	3135	752	5195
F_{rel}_SUM (N/kg)	8.38	1.92	22.9	2.06	8.04	8.73	4.24	14.19
RFD_{rel}_SUM (N/s/kg)	47.61	15.10	31.7	2.85	44.92	50.29	12.55	93.90

Table 3 presents the initial normative data standards for handgrip strength in the Lebanese population, divided by gender and categorized into seven levels ranging from 'Very Poor' to 'Superior.' The classification includes the sum of both hands for absolute and relative values of F_{max} and RFD_{max} for males and females, providing reference values to assess grip strength characteristics in the adult Lebanese population.

Table 3. Handgrip strength initial normative data standards in the Lebanese population by gender

Variables	**Very poor**	**Poor**	**Below Average**	**Average**	**Above Average**	**Excellent**	**Superior**
Males							
F_{max}_SUM (N)	≤596	597-776	777-866	867-1047	1048-1137	1138-1318	1319≥
RFD_{max}_SUM (N/S)	≤3152	3153-4476	4477-5138	5139-6462	6463-7124	7125-8448	8449≥
F_{rel}_SUM (N/kg)	≤7.65	7.66-9.78	9.79-10.85	10.86-12.99	13.00-14.05	14.06-16.18	16.19≥
RFD_{rel}_SUM (N/kg/s)	≤40.17	40.18-56.25	56.26-64.29	64.30-80.38	80.39-88.42	88.43-104.50	104.51≥
Females							
F_{max}_SUM (N)	≤307	308-415	416-468	469-577	578-630	631-738	739≥
RFD_{max}_SUM (N/s)	≤1143	1144-2057	2058-2514	2515-3429	3430-3886	3887-4800	4801≥
F_{rel}_SUM (N/kg)	≤4.53	4.54-6.45	6.46-7.41	7.42-9.34	9.35-10.30	10.31-12.22	12.23≥
RFD_{rel}_SUM (N/s/kg)	≤17.40	17.41-32.50	32.51-40.05	40.06-55.16	55.17-62.71	62.72-77.81	77.82≥

Table 4 presents handgrip strength percentiles for males and females in the Lebanese population. These percentiles offer a reference for assessing grip and explosive strength in this population.

Table 4. Handgrip strength initial standards percentiles for Lebanese males and females

Percentiles		F_{max}_SUM	RFD_{max}_SUM	F_{rel}_SUM	RFD_{rel} _SUM
Males (n=179)	2.5	661	3310	8.34	38.72
	5	684	3943	8.75	45.99
	10	751	4240	9.20	51.62
	30	869	5137	10.42	64.32
	50	944	5759	11.92	71.31
	70	1031	6400	13.23	80.87
	90	1145	7270	14.73	94.56
	95	1314	8071	15.76	98.06
	97.5	1429	8876	16.21	103.98
Females (n=124)	2.5	291	1311	4.60	18.21
	5	322	1370	4.99	22.34
	10	405	1750	5.53	26.26
	30	469	2550	7.42	39.96
	50	526	2904	8.55	48.76
	70	575	3525	9.35	55.69
	90	678	4187	10.89	67.22
	95	706	4498	11.49	72.31
	97.5	760	4682	11.77	75.17

The results presented in Table 5 indicate significant gender differences in all handgrip strength parameters among the Lebanese population. Males showed higher values for both and relative compared to females (Figure 2). The p-values ($p < 0.001$) confirm that these differences are statistically significant, highlighting the distinct variations in handgrip strength between genders.

Table 5. Gender differences in Handgrip Strength parameters in the Lebanese Population

Dependent Variable	**Males (Mean ± SD)**	**Females (Mean ± SD)**
F_{max}_SUM (N)	957 ± 180	523 ± 107***
RFD_{max}_SUM (N/s)	5800 ± 1324	2972 ± 914***
F_{rel}_SUM (N/kg)	11.92 ± 2.13	8.38 ± 1.92***
RFD_{rel} _SUM (N/kg/s)	72.34 ± 16.08	47.61 ± 15.1***

Note: ***Significant at $p < 0.001$.

Figures 2-5 show the hand grip strength values across different countries where Lebanon can be compared. Data are shown for F_{max} and RFD_{max} for males and females.

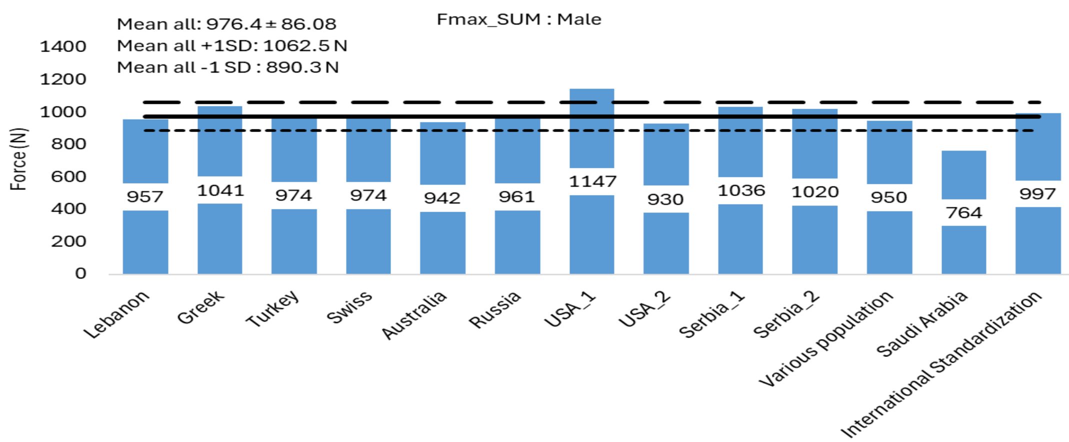

Figure 2. Comparison of current F_{max}_SUM and previously published data for males

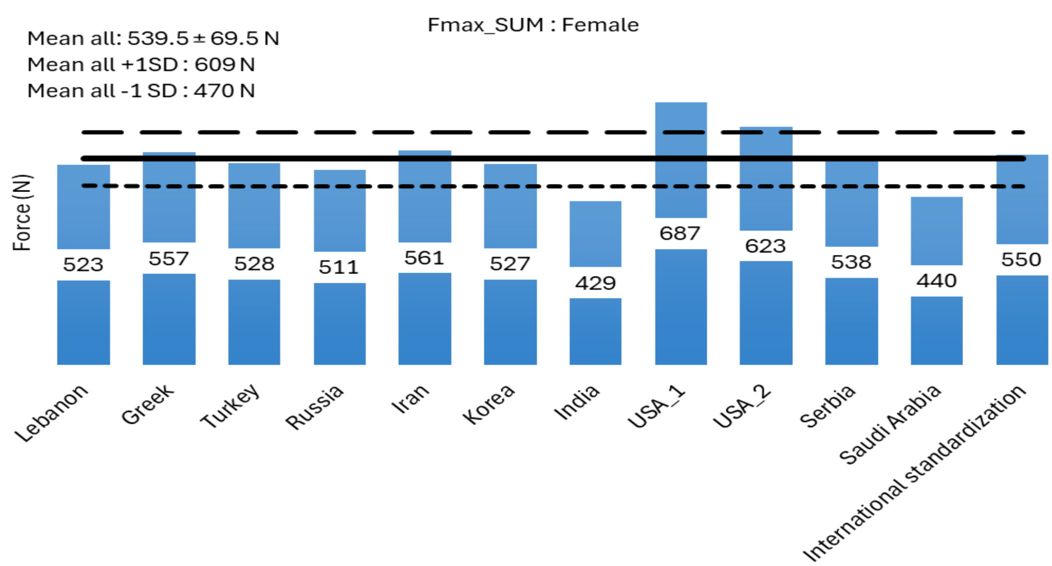

Figure 3. Comparison of current F_{max} _SUM and previously published data for females

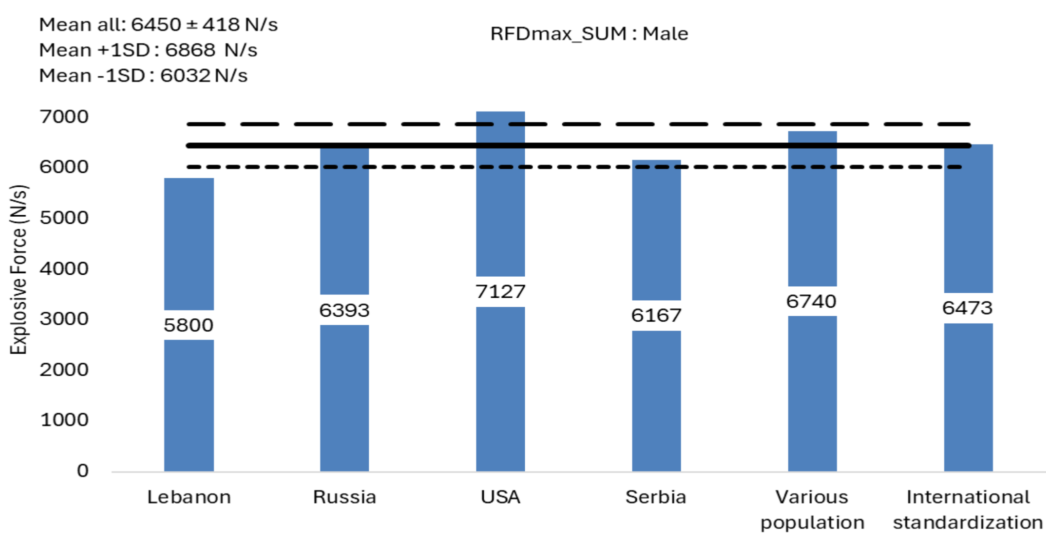

Figure 4. Comparison of current RFD_{max}_SUM and previously published data for males

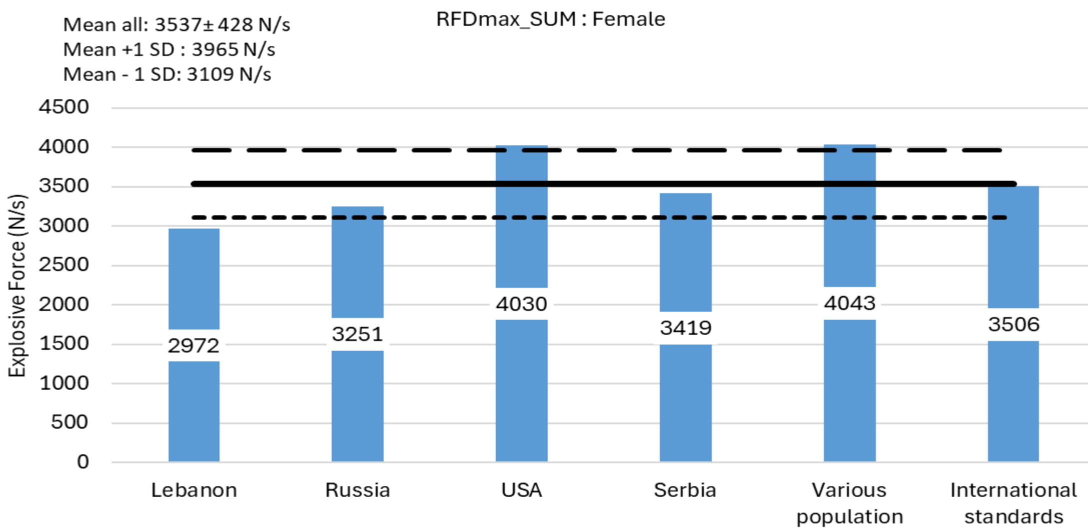

Figure 5. Comparison of current RFD_{max}_SUM and previously published data for females

Discussion

The primary objective of this study is to establish baseline norms for handgrip strength within the Lebanese population, addressing a significant gap in the current data available for this group. Additionally, the study evaluated between-sex differences and evaluated newly defined norms against those from other countries. The descriptive data analysis provided the initial standards for Lebanese population, the between-sex comparison defined the differences between males and females, while the initial standards were compared to international data.

Based on the obtained data, it can be concluded that the values of F_{max}_SUM in males and emales are at the level of 957 ± 180 N, and 523 ± 107 N, while for RFD_{max}_SUM they are at the level of 5800 ± 1324 N/s, and 2972 ± 914 N/s, respectively (Table 2). The relative values showed that Lebanese males and females were able to achieve a total of 11.92 ± 2.13 and 8.38 ± 1.92 hand grip muscular forces per kg of body mass, as well as 72.34 ± 16.08 and 47.61 ± 15.10 N/s/kg hand grip explosive muscle forces per kg of body mass, respectively (Table 2).

The analysis outcomes indicated that the mean values for maximal force are closely aligned with previously reported findings, falling within the range of -1 to +1 standard deviation for both genders. The average handgrip strength in international populations is slightly higher compared to the Lebanese population, with a margin of 1.94% for males and 3.32% for females. Note that the expected between-sex difference in hand grip strength parameters reflected also in comparison of sex-related national data to sex-related international data. However, in terms of the rate of force development, Lebanon did not align with international standards as it was below 1 standard deviation. The difference in the rate of force development between the populations was more significant, with a 10% difference for males and a 15.97% difference for females. The differences in explosive strength observed between the Lebanese population and international counterparts could be attributed to several factors. Ethnic, hormonal and genetic factors play a significant role, as genetic predispositions were reported to influence muscle fiber composition and explosive strength, with variations in muscle fiber types among different ethnic groups partially explaining the differences (Chiu et al., 2020; McGrath et al., 2020; Semenova et al., 2022). Lifestyle and physical activity levels, which vary widely between populations, should also be considered (Hopwood et al., 2023; Domaradzki et al., 2023; Bouchard et al., 1997). In Lebanon, cultural practices, occupational physical demands, and recreational activities might differ from those in other countries, impacting muscle performance. Differences in body composition type, dietary habits and nutritional intake between Lebanese individuals and their international counterparts could contribute to the variance in explosive strength (Ben Mansour et al., 2021; Andraos et al., 2024). Socioeconomic factors could also play a role as these were found to influence physical development and performance, as access to sports facilities, quality of training, and healthcare can vary significantly, impacting opportunities for developing explosive strength (Nieczuja-Dwojacka et al., 2023; Domaradzki et al., 2023).

To further understand these differences, future research should consider several directions. Genetic analysis could investigate genetic markers associated with muscle performance, providing insight into the role of genetic predisposition in explosive strength differences. Collecting comprehensive lifestyle surveys on daily activities, occupational demands, recreational habits, and physical activity levels can correlate these factors with explosive strength metrics. Detailed nutritional assessments can help understand the nutritional influences on muscle performance and identify potential dietary modifications to enhance explosive strength. Implementing and evaluating targeted training programs focused on improving explosive strength in different demographic groups within the Lebanese population and comparing their effectiveness with those used in other countries can offer valuable insights. Exploring the impact of socioeconomic factors on access to training facilities, quality of coaching, and overall physical fitness can help design policies to bridge gaps and promote equitable access to resources for physical development.

A significant limitation of this study is the lack of extensive data on the historical context of the researched populations in Lebanon and other countries, particularly concerning their childhood and adulthood pastimes and daily work activities. These aspects can significantly influence maximal force and rate of force development. To overcome this limitation, future research should adopt a more thorough data collection strategy that includes detailed accounts of physical activity levels, advanced demographics, and work requirements. This data could provide valuable insights into the lifestyle influences on muscular performance, enabling a more nuanced analysis of study outcomes. Moreover, current research on handgrip in Arabic nations is scarce, with only one study conducted in Saudi Arabia. This gap emphasizes the need for further investigation into handgrip dynamics in Arabic countries, considering physical activity patterns, lifestyle choices, and nutritional profiles.

Conclusion

The investigation presents normative data for handgrip strength and explosive strength in the Lebanese population. Handgrip strength outcomes for the Lebanese cohort closely correspond to global standards, showing minimal deviations. However, there is a more noticeable contrast in explosive strength levels between the Lebanese group and international standards, albeit still within acceptable limits. This finding suggests that although Lebanese individuals display similar handgrip strength to their global counterparts, there are noticeable significant differences in explosive strength that necessitate further exploration. Subsequent research should involve a larger sample size to gain a deeper understanding of these distinctions and to verify if the Lebanese populace consistently conforms to global benchmarks in terms of explosive strength. This research establishes a vital reference point for health and performance evaluations in Lebanon. For fitness instructors and trainers, these standards can aid in identifying and nurturing promising athletes by recognizing individuals who meet or surpass the established criteria. Moreover, medical practitioners can utilize this information to evaluate and monitor health hazards, aiming to enhance overall well-being and mitigate risks associated with muscular weakness.

Conflict of interest: All authors declare that they have no conflict of interest relevant to the content of this article.

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