Differences in strength performance between novice and elite athletes: Evidence from powerlifters

Running Head: Novice versus elite strength athletes

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Abstract

Strength forms an integral part of many sports. In particular, powerlifting (PL) success is determined solely by maximal strength, providing a unique opportunity to investigate the differences and potential factors influencing novice and elite competitors. We evaluated performance from 2137 competitors between local (LOC), national (NAT) and international (INT) competitions. Results were analysed by using the total (TOT) competition score within weight classes and age categories. Cohen's *d* effect sizes and 95% confidence intervals were used to detect differences within categories between LOC, NAT and INT competitions. The coefficient of variation (CV) was used to determine the absolute variability. A moderate to large increase in performance was observed for all weight classes between LOC and NAT (males; d=0.76, females; d=1.09). No meaningful differences were observed between LOC and NAT, and NAT and INT when compared using age. No meaningful differences were observed between NAT to INT competitions when compared using weight classes. The CV was not different across competition levels (CV=17.4% - 22.9%) categories. Several internal (athlete) and external (environmental) factors are likely to explain these findings. Therefore, factors such as training experience, performance variability, body composition, anthropometric characteristics and competition pressure that may influence strength performance should also be considered in both training phases and during competition. Collectively, the results offer novel information regarding the difference in strength performance between novice, sub-elite and elite strength athletes. Strength and conditioning professionals should consider these factors when working with various athletes where maximal strength is an important determinant of success.

Keywords:

Elite; novice; competition; squat; bench-press; deadlift

Abbreviations

BP	Bench Press
DL	Deadlift
INT	International
JU	Junior
LOC	Local
M1	Masters 1
M2	Masters 2
M3	Masters 3
M4	Masters 4
NAT	National
PL	Powerlifting
SJ	Sub-junior
SQ	Squat
TOT	Total

INTRODUCTION

Strength is a fundamental component of many athletic disciplines. In sports such as powerlifting (PL), maximal strength is the key, if not the sole determinant of success. In competition, 'raw' powerlifting (i.e., knee sleeves and lifting belt only) makes up the majority of competitions and competitors. Individuals who perform well at local (LOC) competitions are then eligible to partake in national (NAT) competitions and ultimately qualify for international (INT) championships against other nations. However, the differences between, the variability of, and potential intrinsic and extrinsic factors influencing the performance of strength athletes at each level of competition are not well understood.

Despite the growing popularity of PL, there is a scarcity of specific research available for strength and conditioning coaches and athletes. Of the available evidence, the majority has focussed on training practices (13,41), tapering strategies (16,38), lift kinematics (18), body composition and anthropometry (24,25,27), and injury rates (2,10,39). From a competition perspective, only a handful of authors have evaluated performance data from international championship events (1,3,9,23,37). While these articles provide an interesting insight into the different aspects of PL, specific information regarding the differences in performance between novice and elite competitors are lacking.

In other sports (i.e., various football codes and field-based team sports), the physiological and psychological characteristics, and competition demands of amateur, sub-elite and elite athletes are readily available (8,11,22,30,34,42,43). To a lesser degree, this evidence is also available in other strength/power sports (i.e., weightlifting) between LOC and NAT competitors, including athlete profiles (28) and performance differences (15,31,32,29). Collectively, the available evidence in such sports provide valid and reliable information which enables professionals to design and implement specific training programs in order to plan, facilitate and monitor athletic development (17,40). However, given the growing popularity and professionalism of PL, further evidence investigating differences between novice (i.e., LOC), sub-elite (i.e., NAT) and elite (i.e., INT) athletes is desperately required.

Therefore, the purpose of this investigation is to evaluate the differences in strength and performance between novice, sub-elite and elite strength athletes in PL. Furthermore, we aim to explore the magnitude of difference and discuss the potential factors influencing strength performance at LOC, NAT and INT competitions for each weight class and age category in PL athletes. This information will be first of its kind in a maximal strength sport. These findings will provide evidence for strength and conditioning professionals to track athletic development and predict successful performance based upon collective LOC, NAT and INT competition results in PL and potentially other strength-related sports.

METHODS

Experimental Approach to the Problem

PL competition records were collated from the 1st January 2017 to the 31st of December 2017. Data were extracted from publically available databases; Powerlifting Australia, Oceania Powerlifting and the International Powerlifting Federation website(s). Given the public nature of the competition results ethics approval was not required for this project.

Subjects

Data was collated from male and female competitors who competed at LOC and NAT Australian competitions or INT competitions during 2017. Data from international competitions were comprised of all athletes competing at the event (i.e., athletes of any nationality). Permission was granted by Powerlifting Australia to use the competition data for the proposed research, with all individuals/parent/guardians consenting to data use at the time of membership. Due to the publically available nature of the data an ethics waiver was granted by the Deakin University human research ethics committee.

Procedures

Each data set was categorised into individual weight classes for *females:* 47kg, 52kg, 57kg, 63kg, 72kg, 84kg and +84kg and *males:* 59kg, 66kg, 74kg, 83kg, 93kg, 105kg, 120kg and +120kg as well as age category; Sub-junior (SJ) <18 years; Junior (JU) 18-22 years; Open (OP) 23-39 years; Masters I (M1) 40-49 years; Masters II (M2) 50-59; Masters III (M3) 60-69 years; and Masters IV (M4) ≥ 70 years.

Statistical analyses

Performance data was recorded for all competitors from each competition (LOC, NAT and INT) by taking the highest successful weight lifted out of three attempts for the squat (SQ), bench press (BP) and deadlift (DL). The total (TOT) score was the cumulative score of the best successful SQ, BP and DL for each competitor and used in the analysis. In addition, the maximum score in each category was recorded as the highest winning weight achieved for any lift type by any individual in that category for the entire data set in kilograms (kg). Individuals who competed in BP or DL only, equipped competitions, or those who failed to record a TOT score were excluded from the analysis. The precision of mean differences were expressed with 95% confidence limits (95% CL), which defines the range representing the uncertainty in the true value of the (unknown) population mean. This approach is considered more applicable in applied sports settings when providing information for coaches and athletes (21). Qualitative descriptors of standardized (Cohen's *d*) effect sizes were assessed using these criteria: trivial < 0.2, small 0.2-0.49, moderate 0.5-0.79, large >0.8 (12). Effects with CLs overlapping the thresholds for small positive and small negative effects (i.e. exceeding 0.2 of the standard deviation on both sides of zero) were defined as unclear and conversely a clear effect was defined as the 95% CL not exceeding a trivial effect size on both sides of zero (7). Clear small or larger effect sizes were defined as substantial. The coefficient of variation (CV) was initially calculated separately for each individual category using the formula SD/Mean and multiplied by 100 to obtain CV%. Competition level CV was obtained by averaging the CV from all individual categories at that level and a two-tailed independent samples *t*-test used to detect potential differences in CV between competition levels. All calculations were performed in Excel (version 2013; Microsoft Corporation, Redmond, WA). Scores are displayed as the group mean ± SD in kilograms (kg) and are presented for males (Table 1) and females (Table 2).

<Insert Table 1>

<Insert Table 2>

RESULTS

Descriptive statistics

The age range of competitors was males; 15 - 82 years and females; 14 – 77 years, respectively. The body weight of individuals ranged from 52.0 - 201.0 kg and 37.3 – 162.4 kg for males and females, respectively. The dataset included 2137 different individuals across 90 competitions.

The total number of competitors was 1258 males and 879 females, respectively. The total number of individual results was as follows; LOC: 1814, NAT: 105 and INT: 1044.

Absolute reliability

The CV for LOC, NAT and INT competitions were 17.4%, 22.9% and 18.2%, respectively, when averaged across all weight classes. The results of an independent samples two-tailed *t*-test showed no significant difference in the absolute variability of the data between LOC and NAT (p = 0.18) or NAT and INT (p = 0.27) competitions. The CV for LOC, NAT and INT competitions were 20.9%, 19.1% and 19.2%, respectively, when averaged across all age categories. The results of an independent samples two-tailed t-test showed no significant difference in the absolute variability of the data between LOC and NAT (p = 0.85) or NAT and INT (p = 0.92) competitions.

Weight Class

Figure 1 and Figure 2 display the individual TOT scores for females and males, respectively, in comparison to body weight.

<Insert Figure 1>

<Insert Figure 2>

TOT scores were higher in NAT compared to LOC competitions for females in the 47kg (52.8 kg, *d*=1.28, 95% CL = -0.05, 2.61), 52kg (53.9 kg, *d*=1.18, 95% CL = 0.22, 2.13), 57kg (87.9 kg, *d*=1.59, 95% CL = 0.82, 2.36), 63kg (27.6 kg, *d*=0.51, 95% CL = -0.08, 1.10), 72kg (33.4 kg, *d*=0.58, 95% CL = -0.24, 1.39), 84kg (46.5 kg, *d*=0.79, 95% CL = -0.04, 1.61) and 84+kg (102.7 kg, *d*=1.68, 95% CL = 0.51, 2.85) weight classes respectively (Figure 3a). An overall difference was observed for females between LOC and NAT competitions (*d*=1.09, 95% CL = 0.16, 2.00) (Figure 4). No difference in TOT scores were observed for INT compared to NAT competitions within weight classes (Figure 5a). No overall difference was observed for females between NAT and INT competitions (*d*=-0.12, 95% CL = -1.02, 0.78) (Figure 4).

TOT scores were higher in NAT compared to LOC competitions for males in the 59kg (122.7 kg, *d*=1.21, 95% CL = 0.13, 2.29), 74kg (89.5 kg, *d*=1.08, 95% CL = 0.25, 1.91), 83kg (62.1 kg, *d*=0.76, 95% CL = 0.19, 1.32), 93kg (119.5 kg, *d*=1.50, 95% CL = 0.86, 2.14), 120kg (88.3 kg, *d*=0.82, 95% CL = 0.04, 1.60) and 120+kg (93.7 kg, *d*=0.57, 95% CL = -0.13, 1.26) weight classes respectively (Figure 3b). An overall difference was observed for males between LOC and NAT competitions (*d*=0.76, 95% CL = -0.03, 1.54) (Figure 4). TOT scores were higher for INT compared to NAT competitions for the 105 kg (113.7 kg, *d*=0.97, 95% CL = 0.13, 1.81). No differences were observed for any other weight classes between NAT and INT competitions (Figure 5b). No overall difference was observed for males between NAT and INT competitions (*d*=0.00, 95% CL = -0.78, 0.78) (Figure 4).

<Insert Figure 3a and 3b>

<Insert Figure 4>

<Insert Figure 5a and 5b>

Age category

TOT scores were higher in NAT compared to LOC competitions for females in the SJ (207.2 kg, *d*=3.73, 95% CL = 2.07, 5.39), JU (97.9 kg, *d*=1.76, 95% CL = 0.91, 2.60), and OP (66.9

kg, *d*=1.18, 95% CL = 0.75, 1.62) age categories, respectively. No differences were observed for the M1-M4 age categories, respectively (Figure 6a). No overall difference was observed for females between LOC and NAT competitions (*d*=0.76, 95% CL = -0.28, 1.81) (Figure 4). TOT scores were higher for INT compared to NAT competitions for the M1 (48.2 kg, *d*=0.77, 95% CL = 0.03, 1.51), M2 (117.0 kg, *d*=2.12, 95% CL = 0.65, 3.59) and M3 (53.9 kg, *d*=1.41, 95% CL = 0.30, 2.52) age categories, respectively. No differences were observed for the SJ, JU age categories between NAT and INT competitions (Figure 7a). No overall difference was observed for females between NAT and INT competitions (*d*=0.33, 95% CL = -0.64, 1.29) (Figure 4).

TOT scores were higher in NAT compared to LOC competitions for males in the JU (136.8 kg, *d*=1.49, 95% CL = 0.73, 2.24), OP (125.6 kg, *d*=1.40, 95% CL = 1.05, 1.75), and M2 (171.6 kg, *d*=1.99, 95% CL = -0.10, 4.07) age categories, respectively (Figure 6b). No overall difference was observed for males between LOC and NAT competitions (*d*=0.74, 95% CL = -0.29, 1.77) (Figure 4). TOT were higher for INT compared to NAT competitions for the M1 (86.5 kg, *d*=0.73, 95% CL = 0.09, 1.37), and M3 (148.3 kg, *d*=1.56, 95% CL = 0.55, 2.58) age categories, respectively. No differences were observed for the SJ, JU, M2 and M4 age categories between NAT and INT competitions (Figure 7b). No overall difference was observed for males between NAT and INT competitions (*d*=0.28, 95% CL = -0.71, 1.27) (Figure 4).

<Insert Figure 6a and 6b>

<Insert Figure 7a and 7b>

DISCUSSION

To our knowledge, this is the first article to evaluate strength performance between novice, sub-elite and elite competitors in PL. The results suggest an overall difference between LOC and NAT competitions across weight classes for males (d=0.76) and females (d=1.09) while age category results were less clear. No clear effects were observed between LOC and NAT, or NAT and INT competitions when analysed by age categories. Likewise, no clear effects were observed between NAT and INT competitions when analysed using weight classes. In addition, we discuss several potential factors that are likely to contribute to these results. Collectively, the findings suggest that sub-elite powerlifters display greater strength performance compared to novice competitors, however, performances at sub-elite competitions were similar to elite competitions. Professionals should consider using the results to accurately track development and understand the differences between, and the potential factors affecting strength performance in sports requiring a large emphasis on maximal strength.

The results suggest a large difference in performance between LOC and NAT competitions. While this result is not surprising and is routinely observed in other sports (33), consideration should be given regarding the underlying factors. For example, the experience level of athletes competing at LOC competitions is likely to be less than sub-elite or elite competitors. While we were not able to ascertain the experience level of competitors within this study, LOC competitions are often a starting point for many first-time competitors. In particular, skill mastery and physiological adaptations result from high levels of deliberate and specific practice over considerable amounts of time designed to improve performance (14). As highlighted in long-term athlete development models, it may be more feasible to base training and performance assessment on training history rather than chronological age (4). Furthermore, potential differences in anthropometry and body composition should also be considered when interpreting these results (24,25,27). Additionally, it may be argued that older lifters should have acquired much more practice than younger lifters, although it is also important to consider that this is unlikely to directly reflect the sport-specific training age. For example, an M2 athlete may have only participated in one local competition whereas a JU athlete may have competed in several LOC, NAT and INT competitions despite obvious differences in chronological age. Other factors such as performance variability should also be considered in human performance analyses. For example, McGuigan & Kane (32) highlight that lower ranked athletes tend to have a greater intra-individual variability of performance than higher ranked performers likely due to inconsistencies in training and effort. While it may be possible to track within-athlete variability across multiple competitions, this was only achievable for some athletes out of the sample and therefore not considered an accurate representation of intra-individual reliability. Further, the calendar year cross-sectional analysis did not have the ability to determine the training age or competition history of competitors. However, the current results showed that the absolute reliability was similar across all competition levels and the difference between competitor scores remain similar regardless of the competition level. From a practical perspective, coaches should be aware of potential factors that separate performances of less experienced versus more elite strength athletes such as sport specific training experience.

The performance of athletes at NAT and INT competitions were similar with no clear overall effects across weight classes or age categories. There are several possible explanations for these findings. Firstly, the intra-individual variability in the performance of elite athletes were generally small, as has been established in other sports (20,32,35,36). Specifically, Malcata and Hopkins (29) found that the variability in performance of elite athletes in explosive strength sports is low, ranging from 1.4-3.3%. Secondly, the relatively short training time between NAT and INT events (i.e., 2-4 months during 2017 between open and junior/masters nationals, respectively, and the Oceania championships), leaves little room for athletic progression.

Moreover, improvements in performance become smaller over time according to the law of diminishing returns. In support of the current findings, it has also been demonstrated that athletes show less variability in performance within seasons than between (29). Additionally, environmental factors such as increased demands of international events (i.e., travel stress, unfamiliar environment, competition pressure) (29) may also limit or contribute the performance results observed. In fact, evidence suggests that travelling at altitude, jet-lag, sleep deprivation and disturbances in circadian rhythm have an impact on athletic performance (26, 44). To compound this issue, an increase in perceived pressure, anxiety and stress at INT events can potentially affect motor skills and attentional focus (5), which is likely to be exacerbated in individual sports (19). In particular, even a small variability in movement patterns can substantially affect performance in single effort events (6). Therefore, the analysis suggests that the strength-based performance was similar between NAT and INT competitions, however, this result may be influenced by intrinsic and external factors in the lead up to and during competition.

Collectively, the results of this investigation offer novel evidence regarding the differences between novice and elite strength athletes, and discussion of the factors that may contribute to these results. Specifically, the analysis in PL athletes showed a large difference between LOC and NAT competitions despite similarities between NAT and INT competitions. The results suggest that performance in novice powerlifters may be affected by the training status and consistency. The similarity between NAT and INT performances suggests a low variability of sub-elite and elite athletes' strength in powerlifting despite considerable a large between-competitor variance in TOT scores.

PRACTICAL APPLICATIONS

Coaches should consider using this information to track development in strength athletes. Specifically, the information should be used in PL as an indicator of the performance required at each level of competition. Additionally, coaches should understand that the performance of novice athletes is likely to progress rapidly, thus constant re-evaluation of strength levels may be required. Conversely, performances of sub-elite and elite PL strength athletes are likely to be less variable and thus should provide confidence for sub-elite competitors entering into international championships.

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Table 1. Group and winning scores for each weight class in the SQ, BP, DL and TS for females at LOC, NAT and INT competitions, respectively. All data presented as mean ± SD.

Table 2. Group and winning scores for each weight class in the SQ, BP, DL and TS for males at LOC, NAT and INT competitions, respectively. All data presented as mean ± SD.

Figure 1. Effect sizes (ES) and 95% confidence limits (95% CL) between LOC (y-axis) and NAT competitions within weight classes for **(a)** females and **(b)** males, respectively. * indicates a meaningful difference.

Figure 2. Overall effect sizes (ES) and 95% confidence limits (95% CL) for all competitors between LOC and NAT, and NAT and INT competitions when analysed using weight classes or age categories.

Figure 3. Effect sizes (ES) and 95% confidence limits (95% CL) between NAT (y-axis) and INT competitions within weight classes for **(a)** females and **(b)** males, respectively.
* indicates a meaningful difference.

Figure 4. Representation of the TOT scores in comparison to body weight for each female competitor at LOC, NAT and INT competitions.

Figure 5. Representation of the TOT scores in comparison to body weight for each male competitor at LOC, NAT and INT competitions.

Figure 6. Effect sizes (ES) and 95% confidence limits (95% CL) between LOC (y-axis) and NAT competitions within age categories for **(a)** females and **(b)** males, respectively. * indicates a meaningful difference.

Figure 7. Effect sizes (ES) and 95% confidence limits (95% CL) between NAT (y-axis) and INT competitions within age categories for **(a)** females and **(b)** males, respectively. * indicates a meaningful difference.

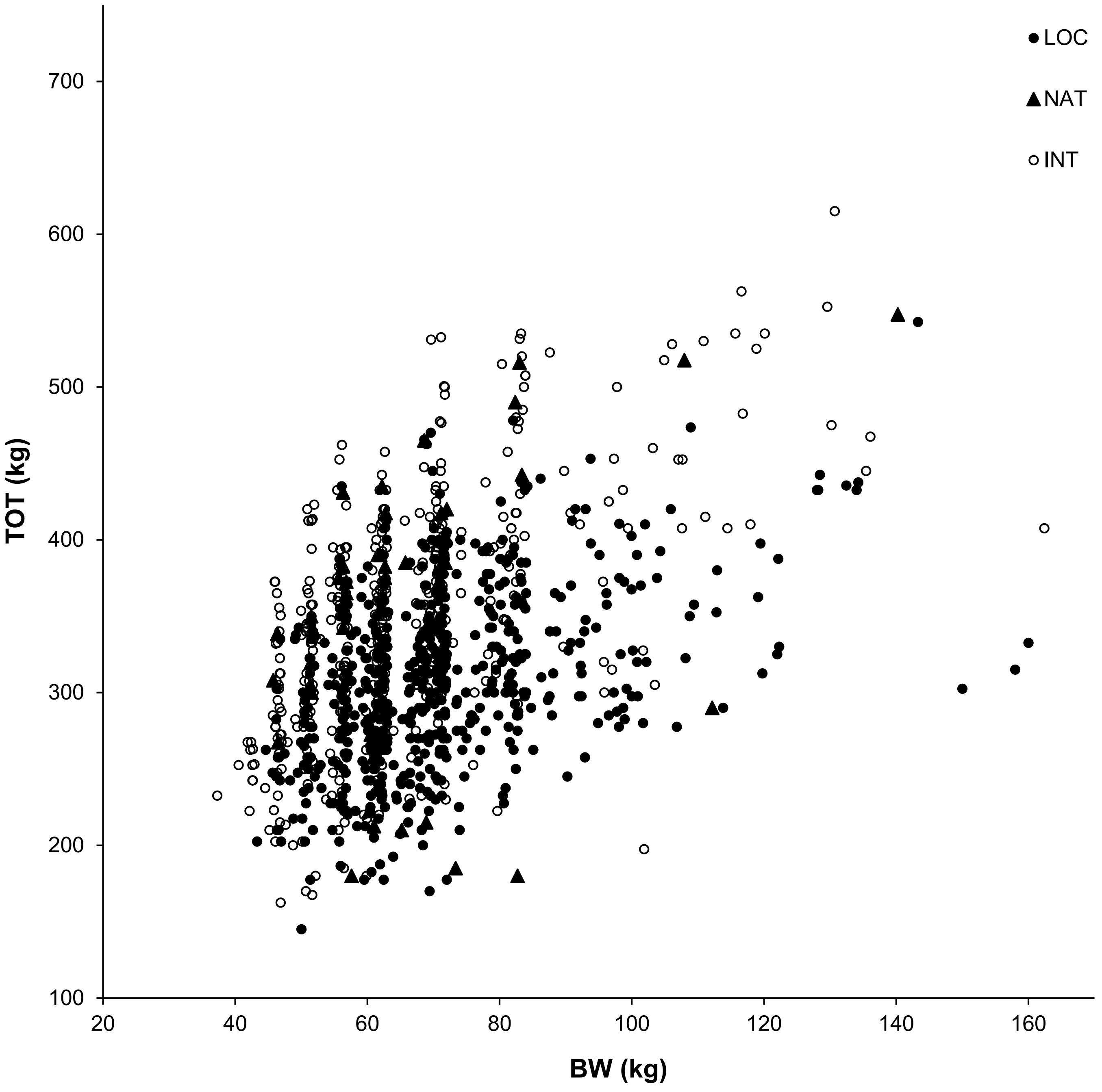
			47kg	52kg	57kg	63kg	72kg	84kg	84+kg
LOC	**SQ**	Grp	86.2 ± 16.7	95.4 ± 19.0	103.5 ± 23.0	104.0 ± 20.8	113.4 ± 23.0	119.5 ± 22.5	129.2 ± 26.7
		Max	*120.0*	*130.0*	*160.0*	*160.0*	*182.5*	*182.5*	*220.0*
	BP	Grp	51.0 ± 12.1	53.4 ± 10.3	58.1 ± 13.7	58.3 ± 10.9	61.4 ± 11.9	65.4 ± 12.9	69.3 ± 13.0
		Max	*70.0*	*80.0*	*87.5*	*92.5*	*90.0*	*95.0*	*115.5*
	DL	Grp	114.8 ± 14.2	120.3 ± 21.4	126.6 ± 23.7	129.0 ± 22.8	138.1 ± 25.1	141.0 ± 23.1	150.4 ± 23.8
		Max	*145.0*	*160.0*	*187.5*	*193.0*	*208.0*	*211.0*	*215.0*
	TO	Grp	251.9 ± 39.5	269.1 ± 46.6	288.2 ± 56.8	291.2 ± 50.2	312.9 ± 56.2	325.8 ± 52.3	349.0 ± 58.0
		Max	*335.0*	*345.0*	*435.0*	*412.5*	*470.0*	*405.0*	*542.5*
NAT	**SQ**	Grp	107.7 ± 17.8	113.5 ± 13.3	134.1 ± 10.6	116.5 ± 39.9	125.4 ± 42.4	133.8 ± 62.7	178.3 71.5
		Max	*125.5*	*127.5*	*157.5*	*165.0*	*175.0*	*195.0*	*220.0*
	BP	Grp	66.0 ± 16.3	62.5 ± 10.6	78.4 ± 7.8	63.3 ± 18.7	72.9 ± 17.6	80.0 ± 33.1	95.8 ± 22.4
		Max	*78.0*	*80.0*	*90.0*	*87.5*	*90.0*	*110.0*	*115.5*
	DL	Grp	131.0 ± 9.0	147.0 ± 5.4	163.3 ± 16.3	139.0 ± 32.8	147.9 ± 48.6	158.5 ± 56.2	177.5 ± 50.2
		Max	*140.5*	*152.5*	*186.0*	*187.5*	*202.5*	*211.0*	*215.0*
	TO	Grp	304.7 ± 35.6	323.0 ± 21.7	376.1 ± 26.0	318.8 ± 89.0	346.3 ± 107.7	372.2 ± 150.8	451.7 ± 140.8
		Max	*338.0*	*350.0*	*431.0*	*435.0*	*465.0*	*490.0*	*542.5*
INT	**SQ**	Grp	97.0 ± 19.0	112.6 ± 23.3	115.7 ± 26.3	123.0 ± 28.8	135.2 ± 25.8	146.3 ± 31.2	170.1 ± 40.7
		Max	*137.5*	*156.5*	*174.5*	*165.5*	*196.0*	*206.5*	*250*
	BP	Grp	56.9 ± 14.4	66.2 ± 15.9	67.5 ± 17.2	70.9 ± 17.4	75.9 ± 18.2	82.8 ± 20.1	94.2 ± 23.3
		Max	*95.5*	*110.5*	*107.5*	*112.5*	*130.0*	*135.0*	*145.0*
	DL	Grp	122.3 ± 18.4	132.6 ± 27.8	143.2 ± 25.7	146.1 ± 23.8	158.0 ± 27.9	165.6 ± 28.0	173.8 ± 27.4
		Max	*170.0*	*182.5*	*187.5*	*200.0*	*237.5*	*215.0*	*220.0*
	TO	Grp	276.2 ± 47.7	311.4 ± 60.8	326.1 ± 62.3	340.0 ± 58.7	369.0 ± 67.9	394.7 ± 74.7	438.2 ± 86.5
		Max	*372.5*	*423.0*	*462.0*	*457.5*	*532.5*	*535.0*	*615.0*

Table 1. Female scores for each lift; SQ = Squat, BP = Bench Press, DL = Deadlift and overall TO = Total for each weight class presented for LOC = Local, NAT = National and INT = international events. Grp = Group scores presented in kg (mean ± SD). Max = Maximum score presented in kg as highest winning score for each respective category.

			59kg	66kg	74kg	83kg	93kg	105kg	120kg	120+kg
LOC	**SQ**	Grp	141.7 ± 46.1	160.4 ± 23.4	172.7 ± 33.2	182.2 ± 31.8	197.4 ± 30.3	202.6 ± 35.2	213.7 ± 44.5	254.6 ± 78.7
		Max	*220.0*	*220.0*	*245.0*	*260.0*	*277.5*	*280.0*	*310.0*	*470.0*
	BP	Grp	88.6 ± 21.1	101.5 ± 17.9	111.3 ± 23.5	119.9 ± 20.8	128.4 ± 20.2	136.1 ± 24.7	138.8 ± 28.5	161.7 ± 39.1
		Max	*125.0*	*145.0*	*172.5*	*175.0*	*177.5*	*212.5*	*207.5*	*270.0*
	DL	Grp	169.6 ± 41.1	191.0 ± 24.1	206.6 ± 31.2	215.5 ± 31.0	229.2 ± 32.8	238.1 ± 38.1	243.1 ± 36.1	264.1 ± 56.2
		Max	*226.0*	*245.0*	*285.0*	*300.0*	*316.5*	*325.0*	*317.5*	*325.5*
	TO	Grp	399.9 ± 104.0	452.8 ± 55.8	490.5 ± 82.5	517.6 ± 76.7	555.1 ± 76.2	577.0 ± 88.3	595.6 ± 100.6	680.4 ± 168.4
		Max	*531.0*	*605.0*	*677.5*	*685.0*	*741.0*	*766.0*	*800.0*	*1070.0*
NAT	**SQ**	Grp	200.6 ± 29.8	163.5 ± 61.2	206.7 ± 28.6	205.8 ± 58.9	240.3 ± 61.7	196.3 ± 73.4	247.5 ± 72.7	291.3 ± 59.9
		Max	*245.0*	*226.0*	*227.5*	*290.5*	*280.0*	*275.0*	*320.0*	*347.5*
	BP	Grp	112.7 ± 13.4	104.6 ± 36.4	135.0 ± 21.0	135.6 ± 32.2	157.5 ± 31.9	130.8 ± 42.9	160.4 ± 43.7	194.6 ± 36.9
		Max	*130.5*	*137.5*	*165.0*	*185.0*	*200.0*	*190.0*	*215.0*	*240.5*
	DL	Grp	209.4 ± 36.7	198.8 ± 43.8	238.3 ± 32.5	238.3 ± 61.8	276.8 ± 67.8	240.4 ± 65.4	276.1 ± 58.2	288.3 ± 46.2
		Max	*232.5*	*250.0*	*275.0*	*302.5*	*318.0*	*312.5*	*345.0*	*352.5*
	TO	Grp	522.6 ± 18.7	466.8 ± 139.8	580.0 ± 77.2	579.7 ± 145.9	674.6 ± 158.4	567.5 ± 178.0	683.9 ± 165.7	774.1 ± 135.8
		Max	*545.5*	*603.5*	*645.0*	*740.5*	*772.5*	*737.5*	*865.0*	*927.5*
INT	**SQ**	Grp	156.1 ± 37.8	179.1 ± 36.2	200.2 ± 35.5	217.1 ± 45.3	232.9 ± 42.0	247.8 ± 46.8	251.2 ± 56.5	282.7 ± 76.7
		Max	*240.0*	*250.0*	*270.0*	*292.5*	*325.5*	*332.0*	*386.0*	*470.0*
	BP	Grp	102.0 ± 23.3	17.1 ± 26.4	129.3 ± 28.4	140.4 ± 29.2	154.3 ± 31.9	163.3 ± 30.6	171.0 ± 34.5	186.9 ± 43.2
		Max	*167.5*	*182.5*	*211.5*	*208.5*	*227.5*	*217.5*	*247.5*	*277.5*
	DL	Grp	180.0 ± 35.4	211.5 ± 37.6	230.0 ± 37.6	248.5 ± 44.4	257.9 ± 38.1	270.1 ± 45.5	264.7 ± 47.1	280.7 ± 53.3
		Max	*265.0*	*285.0*	*292.5*	*325.0*	*322.5*	*380.0*	*347.5*	*377.5*
	TO	Grp	438.1 ± 85.4	507.7 ± 90.1	559.5 ± 91.3	606.0 ± 110.9	645.0 ± 103.1	681.2 ± 111.0	686.8 ± 127.2	750.1 ± 163.2
		Max	*660.0*	*680.0*	*733.0*	*814.0*	*827.5*	*885.0*	*968.5*	*1090.0*

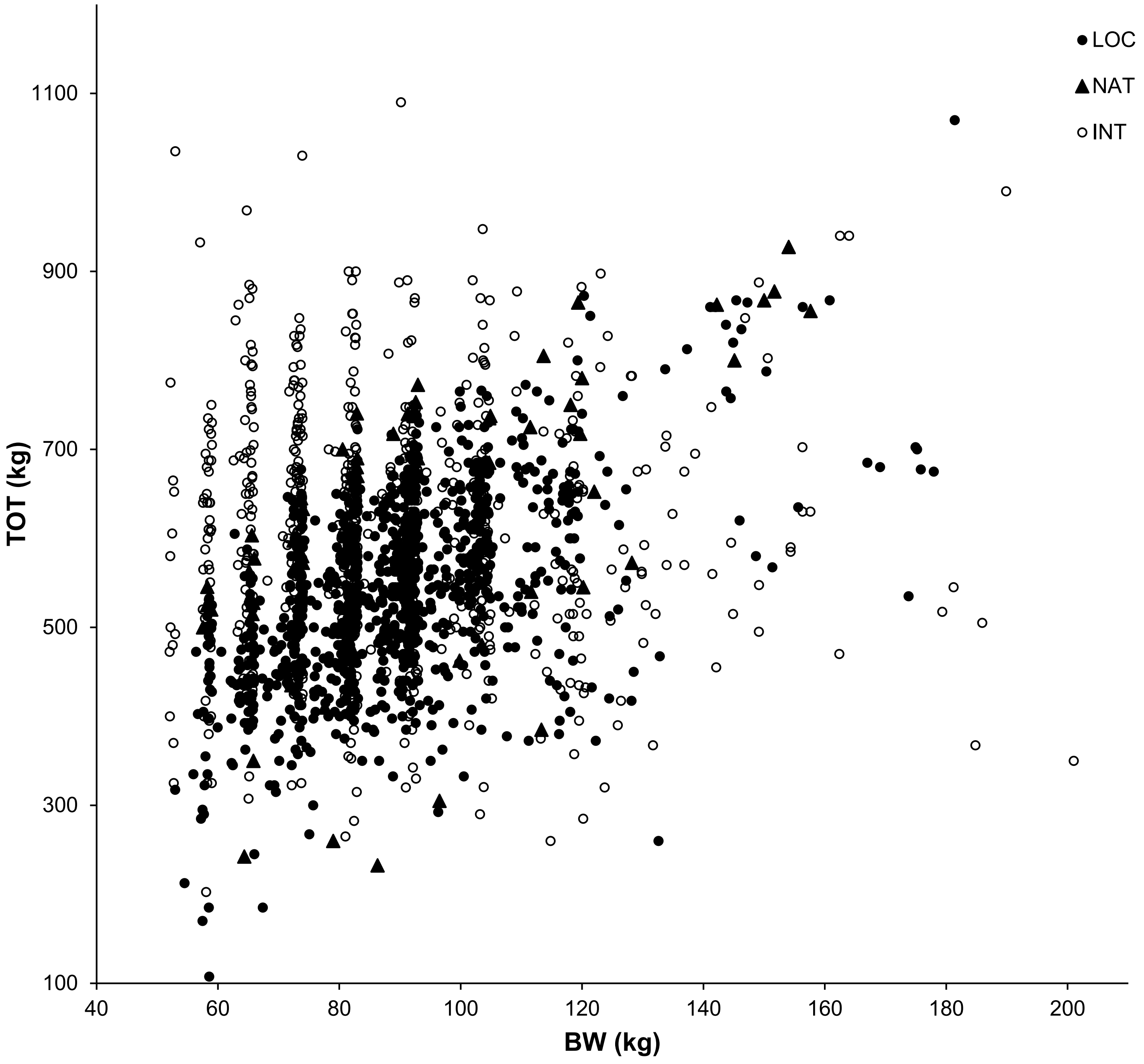
Table 2. Male scores for each lift; SQ = Squat, BP = Bench Press, DL = Deadlift and overall TO = Total for each weight class presented for LOC = Local, NAT = National and INT = international events. Grp = Group scores presented in kg (mean ± SD). Max = Maximum score presented in kg as highest winning score for each respective category.

Figure 1)



LOC
NAT
INT
700
600
500
400
300
200
100
TOT (kg)
20
40
60
80
100
120
140
160
BW (kg)

Figure 2)



LOC
NAT
INT
1100
900
700
500
300
100
TOT (kg)
40
60
80
100
120
140
160
180
200
BW (kg)

Figure 3)

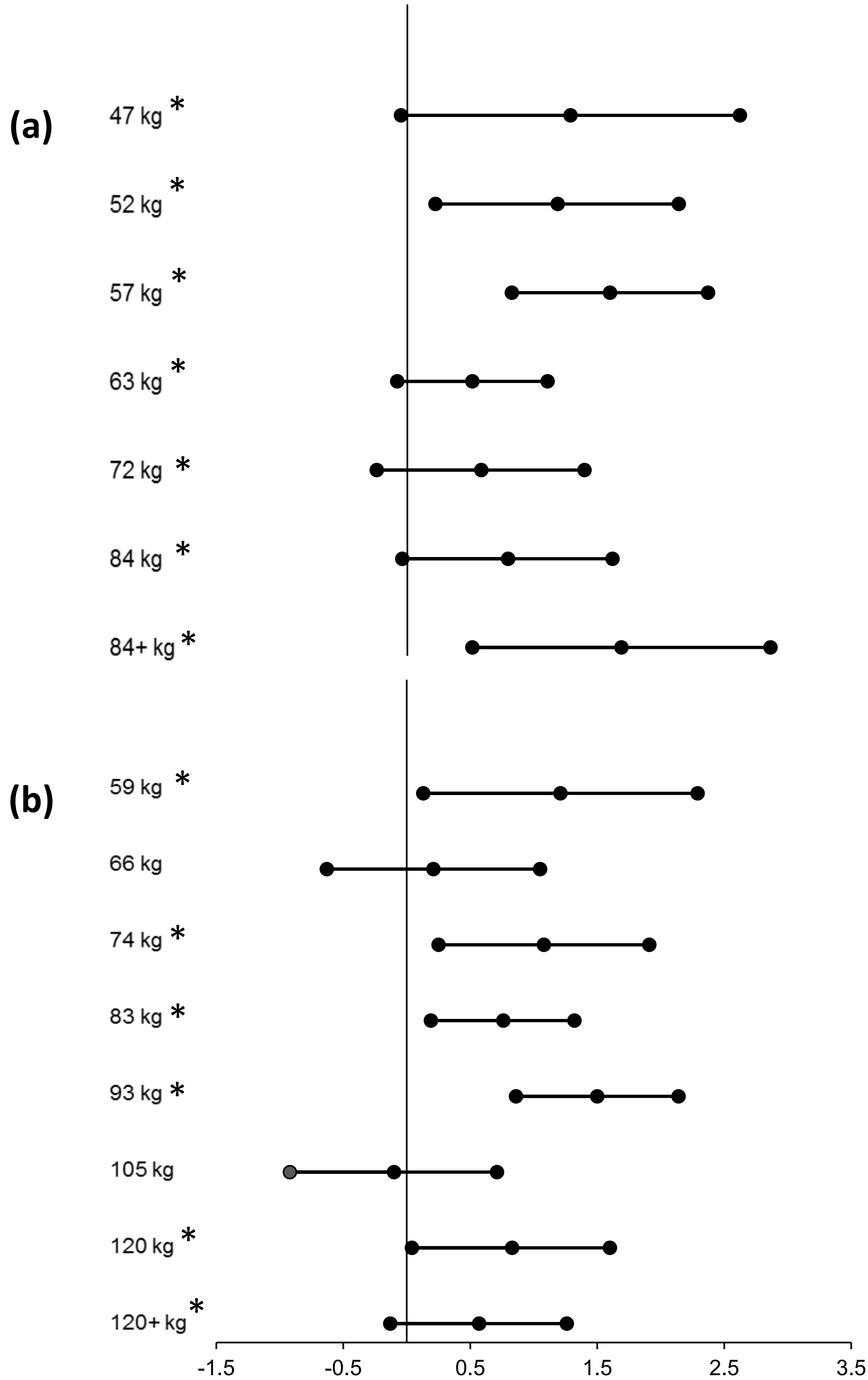


Figure 3 shows the difference between LOC (y-axis) and NAT competition TOT results within weight classes for **(a)** females and **(b)** males. X-axis indicates effect size whilst * indicates a meaningful difference.

Figure 4)

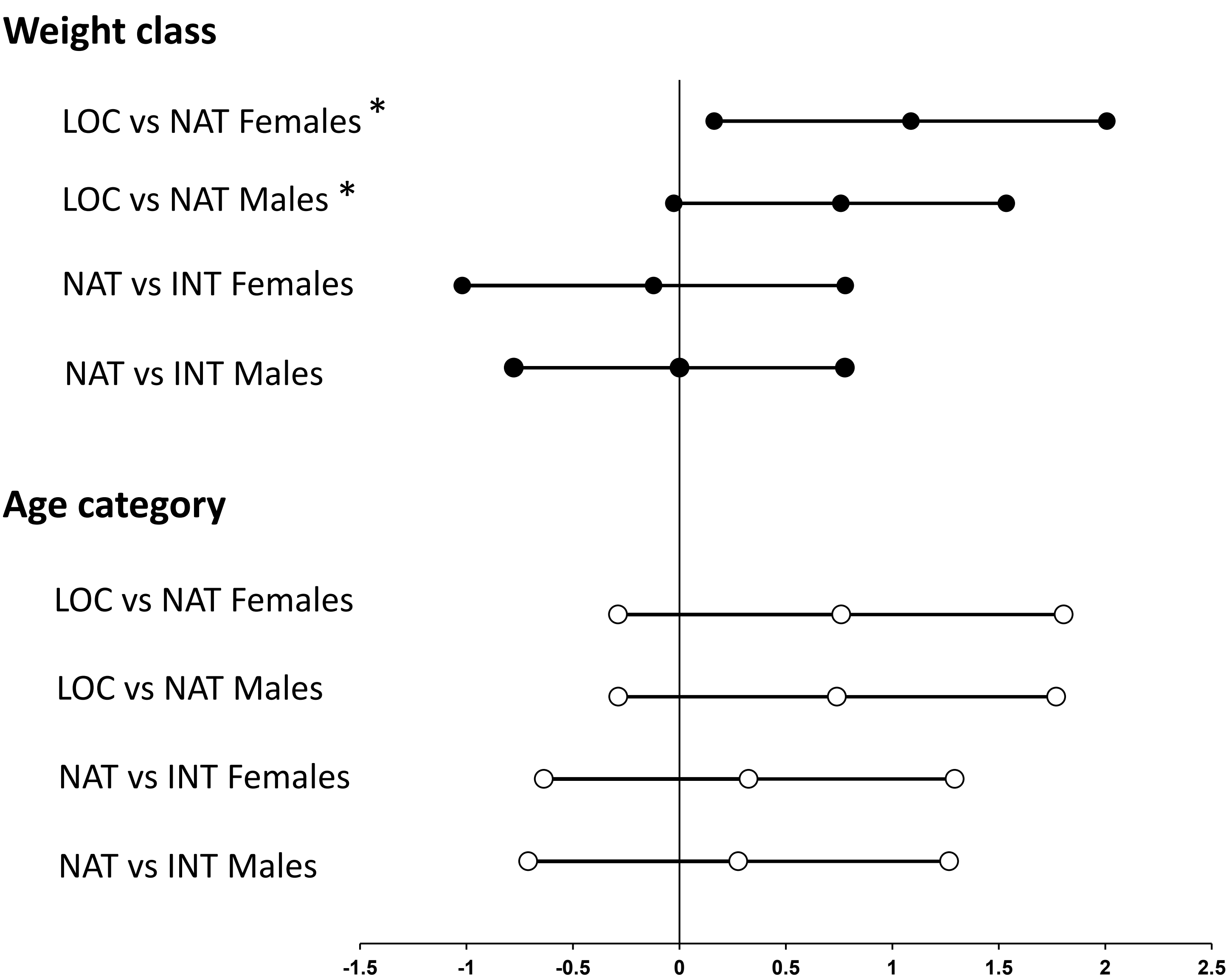


Figure 7 shows the mean effect size difference between competition levels for all combined weight classes and age categories.

Figure 5)

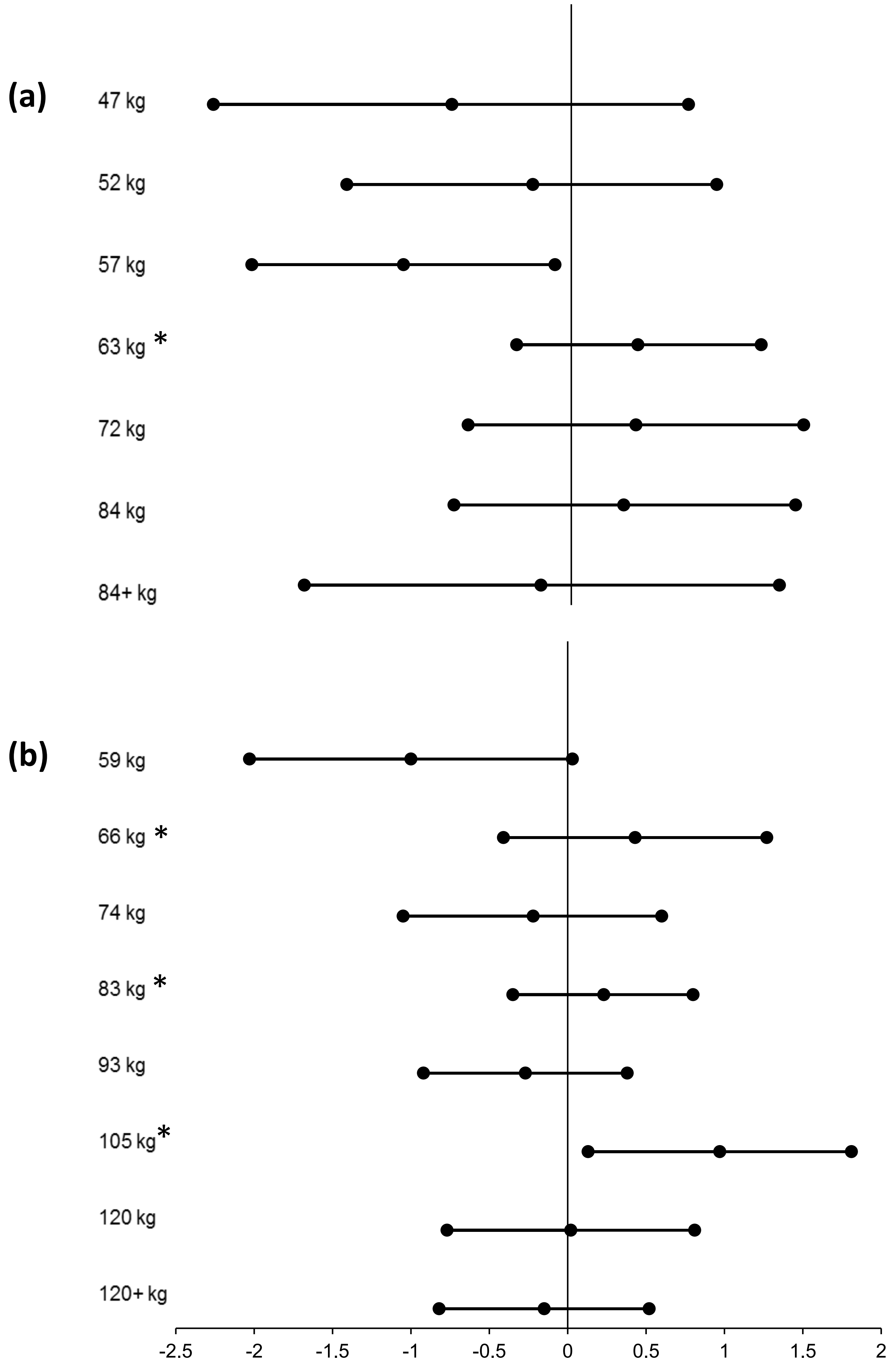


Figure 4 shows the difference between NAT (y-axis) and INT competition TOT results within weight classes for **(a)** females and **(b)** males. X-axis indicates effect size whilst * indicates a meaningful difference.

Figure 6)

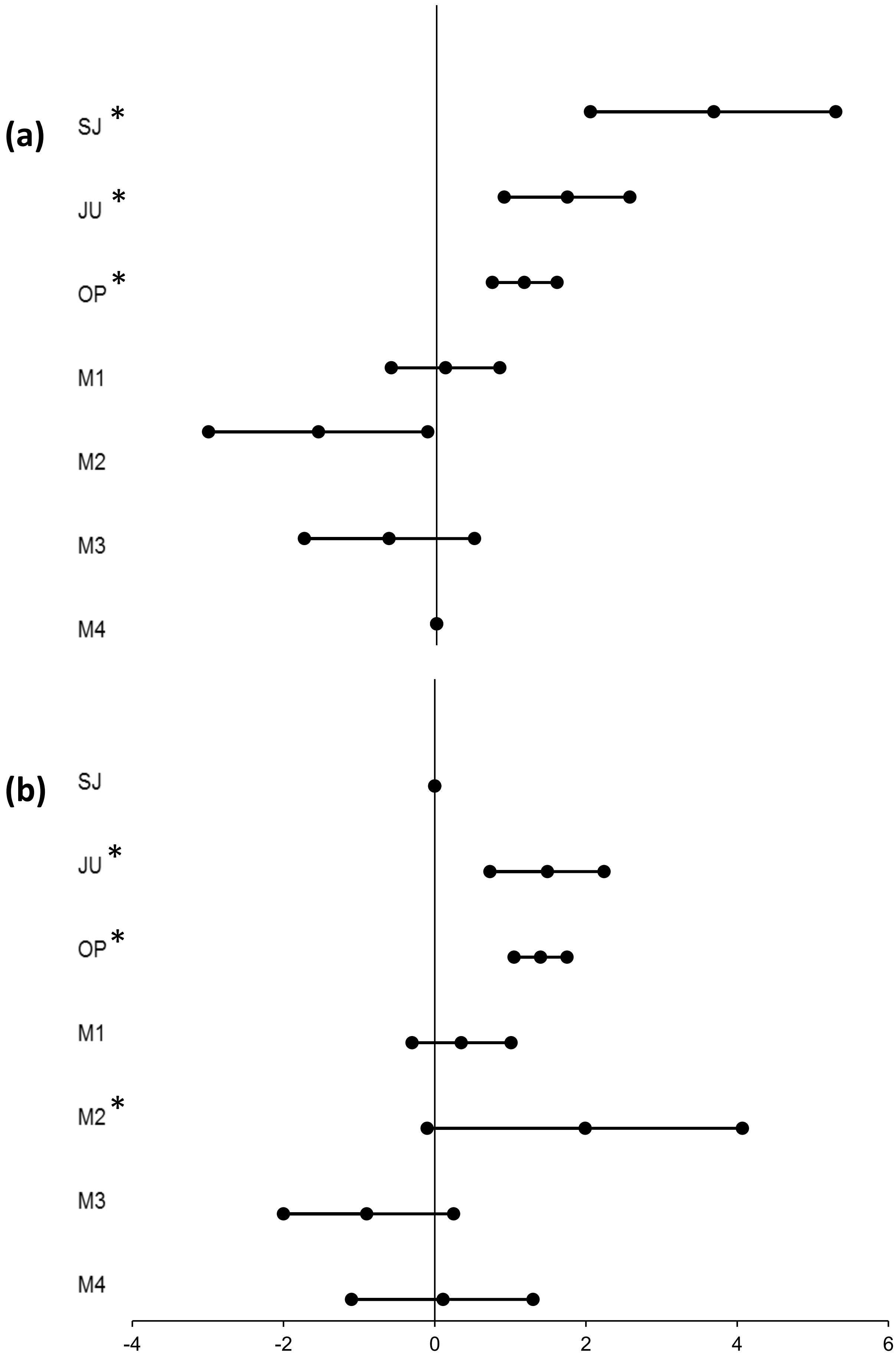


Figure 5 shows the difference between LOC (y-axis) and NAT competition TOT results within age categories for **(a)** females and **(b)** males. X-axis indicates effect size whilst * indicates a meaningful difference.

Figure 7)

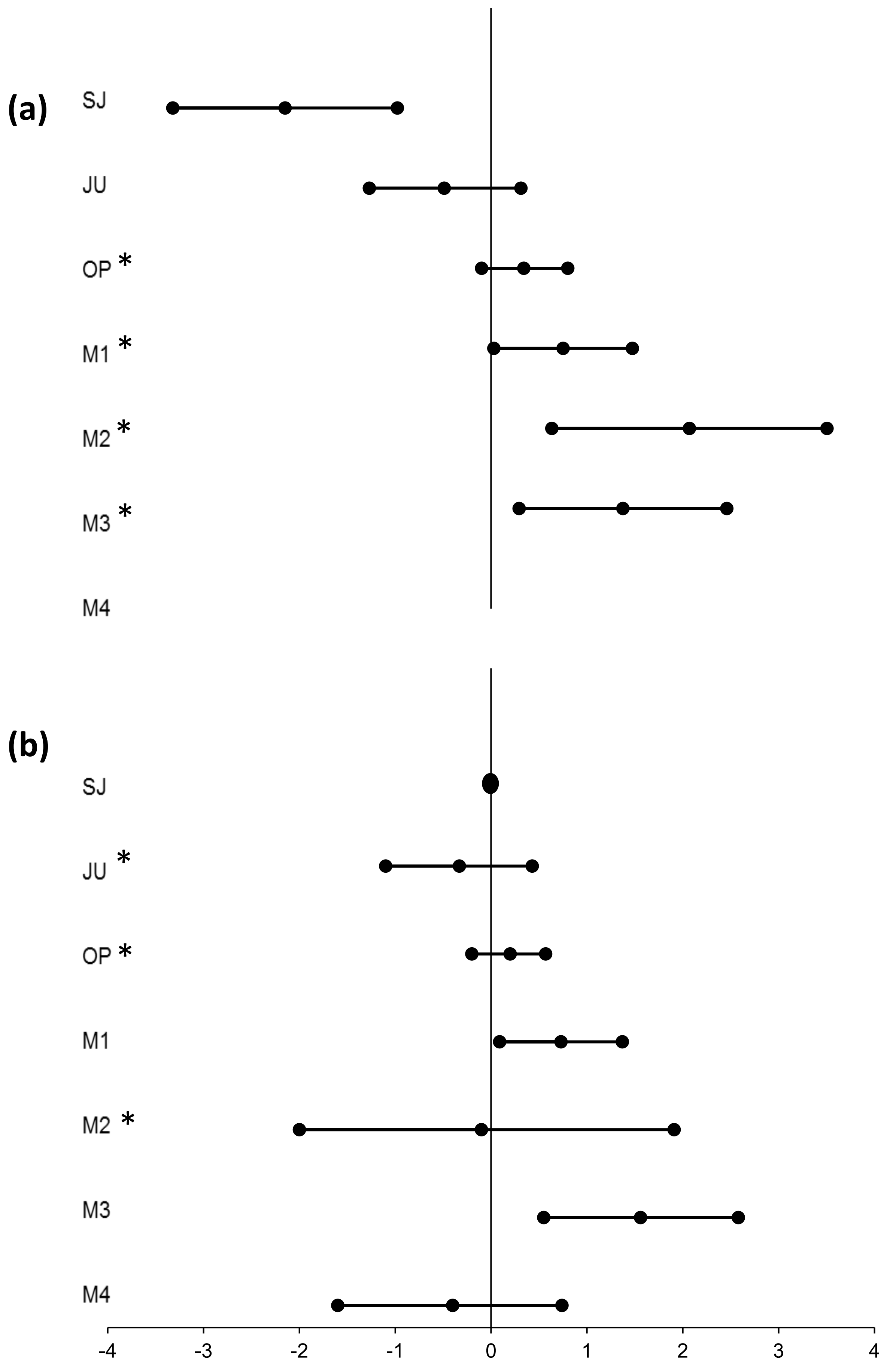


Figure 6 shows the difference between NAT (y-axis) and INT competition TOT results within age categories for **(a)** females and **(b)** males. X-axis indicates effect size whilst * a meaningful difference.