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Anthropometric and Physical Fitness Ability Profile of Elite and Non-Elite Boxers of Manipur

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***Abstract*—**Background: Boxing is one of the oldest combat sports where different anthropological and fitness ability parameters determine performance. It is characterized by short duration, high intensity bursts of activity. The purpose of this research was to determine anthropometric and physical fitness profile of male elite and non-elite boxers of Manipur and to compare the two groups. Materials and Methods: Nineteen subjects were selected as elite boxers and twenty-four were non-elite boxers of Manipur. A cross-sectional study was conducted on anthropometric measurements and physical fitness ability tests on 33 subjects (elite and non-elite boxers). Statistical analysis was done using descriptive statistics, t-test and logistic regression with the help of SPSS version 15 software. Results: Results showed elite boxers have significantly reduced neck girth and calf girth as compare to non-elite boxers. Elite boxers have significantly lower sub scapular skin fold (SSF) and supra iliac skin fold (SISF) than their counterparts. Higher stature, larger BTB and lower percent fat are associated with higher performance in boxing. Sit ups (SU), standing Broad Jump (SBJ), Plat taping (PT), Sit and reach (SAR) and Harvard Step Test (HST) are predicted as most contributing factors enhancing performance level among the physical fitness components. Elite boxers are found to have more functional strength (sit ups), higher explosive strength (SBJ), more agility (PT), cardio-vascular endurance and flexibility (SAR) than non-elite boxers. Conclusion: In conclusion, lower fat, higher lean body mass, larger bi-trochantric breadth, high explosive strength, agility and flexibility are significantly associated with higher performance and chance of becoming elite boxers.

***Keywords*—**Anthropometry, elite and non-elite boxers, Manipur, physical fitness.

I. Introduction

A number of studies provide information on anthropometric characteristics and physical fitness in various sporting events. The findings in most of these studies indicate significant differences in term of anthropometric and selected physical tests between young athletes of different levels or elite and non-elite athletes in various sporting events [1]-[5]. The development of physique in particular sport events seems to have a close link with the development of strength required in most sports performance. Early studies on Olympic competitors revealed that physique was related to a high level of achievement in certain sports [6]. Similarly, selection of Olympic athletes for achieving success in a particular event primarily depends on the specific physique suited to the characteristics of the events [7].

Boxers are required to possess a combination of cardio-vascular endurance, explosive strength, speed, agility and muscular coordination along with suitable physique of the game. Thus, physical activities demand different body size and proportion that is why top level sports men of different sporting events have been found to possess different physique and morphological characters [8] and champions of different athletic and sportive events differ significantly in their physical structure and physiological characteristic that correspond to some extent with the particular requirements of their respective events [9].

The peak performance of boxers is highly influenced by speed and coordination of movements during blows, force of blows and psychomotor abilities [10], [11]. Thus, boxers require to develop high speed, explosive, agility, flexibility and complex expression of coordination abilities during training and coaching [11], [12]. Previous studies on Indian boxers concentrate mainly on body composition, muscle strength, aerobic capacity, and anaerobic power [8], [13], [14]. However. stature and body mass have significant impact on elite boxers. Senior boxers possess tall stature, body mass, lean body mass and body fat compared to junior boxers [15].

Many studies have been conducted on the relationship between human physique and physical performance which indicate the importance of basic structure. Those research studies deal with performance in specific sports, strength measures and the performance of basic motor skills [16]-[19]. The importance of assessing sports-specific skills as well as selected anthropometric and physiological characteristics of athletes in different sporting events is most important to determine their performance level [20], [21]. Therefore, the purpose of the present study was undertaken to compare anthropometric variables and physical fitness ability between the male elite and non-elite boxers and to predict the most potential factors influencing higher performance in the success of boxing competitions.

II. Materials and Methods

Research design: Subjects were tested on two separate sessions as morning and evening sessions. The morning session involved detailed anthropometric measurements, while physical fitness ability tests were performed in the evening session. Standard warm-up procedures were given with 10 minutes of jogging and stretching activities of upper and lower extremities for fitness ability tests. The subjects were fully familiar with the tests procedures to avoid the any negative results. Each boxer was verbally instructed and encouraged during each test to perform maximally at each trial and test. Subjects who are in morbid condition e.g. having diseases like

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diarrhoea, high fever, dehydration and musculo-skeleton abnormalities due to other reasons during the past 10-15 days are excluded from being the subjects of the sample.

Selection of subjects: Forty-three desirable male Meitei elite and non-elite boxers of Manipur were selected of the present study. Out of which 19 boxers at the range of age are categorised as elite boxers as they were medal winners in various National and International competitions and the rest 24 boxers who had poor performance in the competition are categorised as non-elite boxers. The subjects were explained, demonstrated and familiarised with the fitness abilities tests and anthropometric measurements. Data were collected from the elite and non- elite boxers who are actively participating in various competition and regular practice and training.

Study Parameters: Fifteen anthropometric measurements and nine physical fitness ability tests were recorded in this study.

Anthropometric measurements: The anthropometric measurements were carried out: body height (BH), body weight (BW), forearm length (FAL),upper arm length (UAL), bi-acromial breadth(BAB), bi-trochantric breadth (BTB), biceps skin fold (BSF), triceps skin fold(TSF), sub-scapular skin fold(SSF), supra-iliac skin fold(SISF), chest girth (CG), forearm girth FAG), upper arm girth (UAG),thigh girth (THG) and calf girth (CLG).All the anthropometric measurements were recorded by employing the methods laid down by Weiner and Lourie [22].

Body composition: Four derived variables viz. %fat (PBF), total body fat (TBF), lean body mass (LBM) and body mass index (BMI).

Determination of body composition: Skin folds thickness was measured with the help of Holtain skin fold calliper with constant tension to determine the different component of body composition by using the following equations:

% body fat = 0.783 (triceps + sub-scapular skin fold thickness) +1.6) [23]
total body fat or fat mass (kg)= (% body fat x body weight (kg) /100) [24]
lean body mass or fat free mass (kg): body weight (kg)-total body fat (kg) [25]
body mass index: body weight (kg) /Body height (m^2) [26]

Physical fitness ability tests: Nine physical fitness tests were also recorded by employing the methods laid down by AAHPER (American Alliance for Health, physical Education and Recreation) Youth Fitness Test Battery (1976) [27].

Statistical Analysis: Data were presented as mean and standard deviation (±SD). Student's t-test was used to determine the significant differences of mean in each parameter between elite and non-elite boxers. Multiple logistic regression is also used to predict the most influencing variables in achieving the performance level of the boxers. Statistical soft ware package (SPPS-16) was used in the study.

III. Results

Considering the two categories of elite and non-elite boxers, Table I reveals the average values of age (19.74 yrs ± 1.88 vs. 19.25 yrs ± 1.29) and body height (165.43 c m ± 7.52 vs. 164.46 cm ± 6.46) are found to be visibly higher in elite boxers than that of non-elite boxers. However, no statistical significant differences are observed between the groups. The upper arm length of elite boxers is found to be higher as compared to non-elite boxers. A lower mean value of BAB is observed in elite boxers when compared to non non-elite boxers (38.99 cm ± 1.92 vs. 39.16 cm ± 1.10). On the contrary, elite boxers are found to have higher mean value in BTB (28.68 cm ±1.51) than the non-elite boxers (28.19 cm ± 1.41).

Statistical significant differences are observed in sub-scapular skin folds (t=2.106: P<0.05) and supra iliac skin folds (t=2.120: P<0.05) between the groups. However, no significant differences are observed in biceps and triceps skin fold thickness between the groups. Decreasing trend of skin fold thickness is witnesses in elite boxers as compare to non-elite boxers. Elite boxers posses marginally smaller in CG, UAG and THG as compared to non-elite boxers. Significant differences are observed in FAG (t=2.43: P<0.05) between the groups. In the measurements of lower extremities, calf girth is found to have statistically significant (t=2.55: P<0.05) between the group.

TABLE I
Descriptive Statistics of Anthropometric Measurements of Male Elite and Non-Elite Boxers

Anthropometric parameters	Elite Boxers		Non-Elite Boxers		t-value (p)
	Mean	SD	Mean	SD	
Age (yrs)	19.74	1.88	19.25	1.29	1.04 (0.321)
Body Height (cm)	165.43	7.52	164.63	6.46	0.375(0.709)
Body weight (kg)	53.42	6.30	55.39	5.22	1.123(0.268)
FAL(cm)	24.19	1.50	24.34	1.13	0.365(0.717)
UAL (cm)	31.11	2.20	30.99	1.47	0.211 (0.834)
Transverse Measurements(cm)					
Bi-acromial Breadth	38.99	1.91	39.16	1.09	0.370(0.713)
BTL	28.68	1.51	28.19	1.41	1.113(0.272)
Skin fold measurements(mm)					
Biceps skin fold	3.55	0.50	4.01	1.00	1.830(0.075)
Triceps skin fold	6.05	1.93	6.75	1.85	1.210(0.233)
SSF	8.35	1.59	10.34	3.84	2.106(0.041)*
SIF	6.13	1.17	7.30	2.17	2.120(0.040)*
Girth Measurements(cm)					
Chest girth	83.15	3.38	84.81	3.71	1.513(0.138)
Forearm girth	24.49	1.37	25.28	0.72	2.437 (0.019)*
Upper arm girth	24.98	1.56	25.77	1.23	1.868 (0.069)
Thigh girth	48.03	2.89	48.97	2.22	1.198(0.238)
Calf girth	33.16	1.82	34.40	1.35	2.559(0.014)*

*P<0.05.

Table II reveals that there is a general decreasing trend in % body fat (13.82 ± 4.29 vs.16.06 ± 4.29), total body fat (7.49 ± 2.38 vs. 8.98 ± 2.85) lean body mass (45.92 ± 4.58 vs.46.41 ± 4.17) in elite boxers as compared to non-elite. However no significant differences are found in these variables. By observing the body compositions of elite boxers of Manipur; they are approaching on the line of meso-ectomorphic characters. The lower level of PBF, TBF and LBM of the present study particularly in elite boxers is found to have very nearer to the level of Olympic boxers [28]. Elite boxers is

significantly lower BMI (19.46 ± 1.08) than the non-elite boxers (20.41 ± 1.04) though both are falls in the normal BMI.

It is evident from the Table III that significant differences are found in sit ups (t=4.45: P<0.001), shuttle run (t=4.51: P<0.001) and sit and reach (t=2.24: P<0.05) respectively. Sit ups, shuttle run and sit and reach were used to measure abdominal strength or functional strength, speed, agility and flexibility respectively. No significant difference in SBJ is observed in between them. Plate tapping is used to assess the flexibility. Elite boxers have more flexibility than the non-elite boxers but there is no significant difference between the groups. Elite boxers are having more cardio-vascular endurance than non-elite boxers. Significant differences in cardiovascular endurance determined by Harvard step test was observed (t=4.32: P<0.01) between the groups.

TABLE II
DESCRIPTIVE STATISTICS OF BODY COMPOSITION OF MALE ELITE AND NON-ELITE BOXERS

Parameters	Elite Boxers		Non-Elite Boxers		t-value (p)
	Mean	SD	Mean	SD	
Percent fat (% fat)	13.82	3.04	16.06	4.29	1.919 (0.062)
Total body fat (kg)	7.49	2.38	8.98	2.85	1.822 (0.076)
Lean body mass (kg)	45.92	4.58	46.41	4.17	0.364(0.718)
BMI (kg/ m²)	19.46	1.02	20.41	1.21	2.725(0.009)*

*P<0.05.

TABLE III
DESCRIPTIVE STATISTICS OF PHYSICAL FITNESS ABILITY TESTS OF MALE ELITE AND NON-ELITE BOXERS

Parameters	Elite Boxers		Non-Elite Boxers		t-value (p)
	Mean	SD	Mean	SD	
SBJ (m)	2.341	26.83	2.312	14.48	0.432(0.668)
Sit ups (second))	57.2	7.63	44.95	10.12	4.452(0.000)**
Shuttle run (Sec)	9.10	0.33	9.63	0.41	4.509(0.000)**
SAR (inches)	19.86	1.66	18.68	1.79	2.240(0.031)*
PT (second)	70.31	6.42	66.54	8.15	1.652 (0.109)
HST	81.59	4.54	73.51	7.06	4.323(0.000)**
RHG(kg)	43.10	5.66	44.89	5.68	1.027(0.310)
LHG(kg)	41.39	6.04	43.22	5.30	1.059 (0.296)
BT (second)	116.95	67.77	88.87	1.401	1.401(0.169)

*p<0.05; **p< 0.001; SAR=Seat and Reach; HST= Harvard Step Test; RHG= Right hand grip; LHG= Left hand Grip; BT=Balance Test.

The age of Manipuri elite boxers was found to be younger (19.74 yrs) when compared to Olympic boxers (23.06 yrs), Indian boxers (22.10 yrs) and Nepal Army boxers (22.10 yrs). When we compare the body weight and body height of Olympic boxers without classifying them into different weight categories, it is found that Manipuri elite boxers are shorter in height (165.43cm vs. 170.06 cm) and lighter in weight (53.42 kg vs.58.56 kg). However, the mean value of BMI (19.46 kg m² vs.19.99 kg/m²) is very close with Olympic boxers. While comparing the body composition between elite Manipuri boxers and Olympic boxers it is found that elite Manipuri boxers have lower % fat (13.8% vs. 14.5%). It is also observed that the Indian boxers are having more % fat compared to Olympic boxers (16.4% vs. 14.5%) and Manipuri boxers (16.4% vs. 13.8%). Interestingly, it is also evident from that no significant differences are observed between the Manipuri elite boxers and Olympic boxers in biceps (3.6 mm vs. 3.0 mm) triceps (6.2 vs. 6.0 mm) and SSF (8.4mm vs. 9.0 mm) skin fold thickness measurements (Table IV). To identify the most influential variables/factors among the eight factors or variable of interest, the dichotomous multivariate logistic regression is applied. After adjusted the joint effect of eight variables, five variables viz. age, BH, BTB, THG, LBM and % fat are identified as significant impact on the two level of players (elite and non-elite boxers). The results indicate that higher stature, larger BTB, medium thigh girth, optimum lean body mass and lower percent fat may be associated with higher performance in boxing (Table V).

TABLE IV
DESCRIPTIVE STATISTICS FOR COMPARISON BETWEEN PRESENT DATA (ELITE BOXERS) AND OTHER AVAILABLE SECONDARY DATA

Teams and reference	Age (Yr)	BW (Kg)	BH (cm)	BMI Kg/m²	% PF	LBM	TBF
Nepal Army Boxers [29]	24.48	66.43	170.13	22.90	9.58	44.43	-
Indian boxers [15]	22.10	76.70	179.00	23.93	16.4	53.1	-
Olympic Boxers [30]	23.06	58.56	170.06	19.99	14.5	-	-
Boxers of Kolkata, India [31]	21.55	58.55	167.09	20.99	8.81	53.38	6.48
Manipuri Elite Boxers, India (Present Study)	19.74	53.42	165.43	19.46	13.8	45.92	7.49

TABLE V
MULTIPLE LOGISTIC REGRESSION ANALYSIS OF DESIRABLE PHYSICAL FITNESS ABILITY OF ELITE AND NON-ELITE BOXERS OF MANIPUR

Anthropometric Parameters		Regression coefficient	p-value	Odds Ratio(OR)	95.0% C.I. for OR	
					Lower	Upper
Step 1(a)	Age	.504	.178	1.655	.795	3.446
	BH	.342	.058	1.407	.989	2.003
	BTB	1.202	.014	3.326	1.280	8.643
	CG	-.137	.507	.872	.582	1.306
	THG	.657	.058	1.929	.977	3.810
	LBM	-1.557	.030	.211	.052	.860
	TBF	3.412	.315	30.327	.039	23.629
	% fat	-2.944	.185	.053	.001	4.109
	Constant	-33.126	.494	.000		
Step 2(a)	Age	.476	.192	1.609	.787	3.292
	BH	.370	.034	1.448	1.029	2.038
	BTB	1.167	.014	3.213	1.269	8.135
	THG	.695	.044	2.005	1.018	3.947
	LBM	-1.557	.027	.211	.053	.837
	TBF	2.861	.365	17.485	.036	85.86
	% fat	-2.629	.209	.072	.001	4.361
	Constant	-49.851	.224	.000		
Step 3(a)	Age	.632	.073	1.881	.942	3.756
	BH	.401	.017	1.493	1.073	2.078
	BTB	1.165	.019	3.207	1.212	8.485
	THG	.693	.044	2.000	1.020	3.924
	LBM	-1.103	.004	.332	.155	.710
	% fat	-.797	.006	.451	.256	.793
	Constant	-82.753	.005	.000		

Table VI reveals the result of stepwise multiple logistic regression (backward wald) selecting eight variables of interest. Out of these variables only two variables-sit ups and Harvard step test are predicted is to be most important factors influencing higher performance on the two levels of players

(elite and non-elite boxers). It is quantified by OR: 1.147 with 95% CI 1.025-1.284 and OR: 1.231 with 95% CI 1.04-1.45. It may also be interpreted as 1(one) complete cycle increased in sit-ups of boxer, the chance or probability of becoming elite players is increased by 14% (OR: 1.147 with 95% CI 1.025-1.284). In boxing event, abdominal strength indicated by sit-ups and cardio-vascular endurance assess by Harvard step test can be taken into consideration as one of the influencing factors in boxing performance. These two variables are also detected by t-test as highly significant (P<0.01).

TABLE VI
MULTIPLE LOGISTIC REGRESSION ANALYSIS OF DESIRABLE PHYSICAL FITNESS ABILITY TEST OF ELITE AND NON-ELITE BOXERS OF MANIPUR

Parameters		Regression Coefficient	p-value	Odds Ratio(OR)	95.0% C.I. for OR	
					Lower	Upper
Step 1(a)	SBJ	.032	.213	1.033	.982	1.086
	SU	.116	.120	1.123	.970	1.299
	SR	-.608	.763	.544	.010	28.248
	HST	.290	.028	1.336	1.032	1.730
	HGR	-.111	.346	.895	.711	1.127
	LWBT	-.003	.776	.997	.979	1.016
	SAR	.463	.210	1.588	.770	3.275
	PT	.081	.437	1.085	.884	1.331
	Constant	-40.084	.197	.000		
Step 2(a)	SBJ	.030	.219	1.030	.982	1.080
	SU	.118	.116	1.125	.971	1.303
	SR	-.513	.798	.599	.012	30.184
	HST	.285	.028	1.330	1.031	1.715
	RHG	-.112	.339	.894	.710	1.125
	SAR	.450	.221	1.569	.763	3.227
	PT	.065	.454	1.067	.901	1.263
	Constant	-39.024	.207	.000		
Step 3(a)	SBJ	.032	.169	1.032	.987	1.080
	SU	.130	.032	1.139	1.011	1.283
	HST	.290	.024	1.337	1.038	1.721
	RHG	-.124	.260	.884	.713	1.096
	SAR	.484	.170	1.623	.812	3.244
	PT	.069	.415	1.071	.908	1.265
	Constant	-45.800	.007	.000		
Step 4(a)	SBJ	.027	.225	1.027	.984	1.072
	SU	.136	.019	1.145	1.022	1.283
	HST	.256	.022	1.292	1.038	1.607
	HG	-.117	.277	.890	.721	1.098
	SAR	.568	.095	1.765	.907	3.438
	Constant	-39.384	.004	.000		
Step 5(a)	SBJ	.020	.341	1.020	.979	1.062
	SU	.137	.017	1.147	1.025	1.285
	HST	.235	.019	1.265	1.040	1.537
	SAR	.399	.136	1.490	.882	2.519
	Constant	-37.987	.002	.000		
Step 6(a)	SU	.129	.018	1.138	1.023	1.266
	HST	.231	.017	1.260	1.043	1.522
	SAR	.425	.112	1.530	.905	2.586
	Constant	-33.191	.002	.000		
Step 7(a)	SU	.137	.017	1.147	1.025	1.284
	HST	.207	.013	1.231	1.044	1.450
	Constant	-23.599	.001	.000		

IV. DISCUSSION

The main objective of the present study was to assess and compare various anthropometric characters and physical fitness level between elite and non-elite boxers. The results of this study demonstrate that significant differences exist in sub-scapular skin fold, supra-iliac skin fold, fore arm girth and calf girth between the groups. Suitable physique is important to achieve success in particular sports [32]. Judging the performance of the human body by its size, shape and form has been a topic of great concern. In the present day of tough competition, when scientific principles are applied for training of athletes, the size, the shape and the form of the body coupled with its efficiency in performance have been given more importance especially from the point of view of identifying, selecting and developing the talent in sports [33], [34]. Based on the step-wise binary logistic regression analyses reveals that higher stature, larger BTB, medium thigh girth, optimum lean body mass and lower percent fat is identified as suitable physique of the game and these are associated with higher performance in boxing.

Recent researches in this field of sports sciences have clearly established that various physical activities demand different body size and proportions that is why top-level sports men of different sportive events have been found to possess different physique and morphologic characteristics [8]. Stature and body mass have significant impact on elite boxers [15]. Elite male boxers of Manipur possess higher stature, body mass, lean body mass and less body fat compared to non-elite boxers.

The estimation of body composition permits the quantification of gross size of an individual into two major structural components namely fat mass and lean body mass [35]. This accurate appraisal provides an important baseline to develop an effective training program. It is widely believed that there are ideal body weights and body compositions for specific sports. Body fat plays an important role for the assessment of physical fitness of an athlete. The present findings reveals that lower% BF and TBF might have influence in boxing performance. The finding is having a little contradiction with the findings of earlier studies conducted by Khanna and Manna [15]. They reported that body mass and body fat is significantly higher in senior Indian boxers as compared to junior boxers. It indicates that the somatotype of Indian boxers found to have constant status in meso-endomorphic [15] instead of meso-ectomorphic. Meso-ectomorph is the optimal somatotype of elite players [28].

Evidence from sports participants in various age groups has demonstrated an inverse relationship between fat mass and performance of physical activities requiring translocation of the body weight either vertically, such as in jumping, or horizontally, as in running [36]-[38]. Excess fatness is detrimental to these types of activities because it adds mass to the body without additional capacity to produce force. Because acceleration is proportional to force but inversely proportional to mass, excess fat at a given level of force application will result in slower changes in velocity and direction [36], [39].

Lower % fat and body mass is observed in Manipuri Elite boxers as compare to non-elite boxers. Excess fatness also increases the metabolic cost of physical activities that require

movement of the total body mass [40]. Thus, in most performances involving movement of the body mass, a relatively low %BF should be advantageous both mechanically and metabolically [36]. The average BMI value of elite boxers is lower than non-elite boxers within the normal range of BMI. It indicates that lower value of BMI might have influenced in boxing performance. Low level of BMI may helps in movements and changing pace. However, greater body mass and BMI are strongly related with success in the game of football [41]. It has been reported reducing their body weight prior to completion so as to gain a physiological and psychological advantage over the opponents in the same weight category [42]-[44]. It has been reported that modification to a wrestlers training and diet over a 53-day period resulted in the loss of 12.7% body weight [45]. However, inappropriate methods of weight loss could result in an amateur boxer entering the ring in a dehydrated and glycogen –depleted state, leading to impaired performance and an increased risk to health [46].

As boxing is a combat sports, many activities are forceful and explosive (e. g. punches, agility, flexibility, changing pace etc.). The power output during such activities is related to the strength of the muscles involved in the movements. Thus, it might also diminish the risk of injury [47]. The physical fitness profile of elite Croatian female Taekwondo athletes was assessed to differentiate the successful from less successful fighters [48]. The higher level of SBJ, SR, HST, SU, SAR and PT observed in male elite boxers may be due to their high level physical conditioning training and coaching as compared to non-elite boxers. The present findings based on the binary logistic regression also predict abdominal strength assessed by sit-up test and cardio-vascular endurance indicated by Harvard Step test are the most influencing factors on boxing performance.

V. Conclusion

The overall findings of the present study reveal that less significant variations are observed in anthropometric parameters as compared to physical fitness ability tests between the elite and non-elite boxers. In other words significant differences are more pronounced in physical fitness tests than the anthropometric variables. The present study depicted that long term boxing training can be achieved appropriate physique and physical fitness level. The higher abdominal strength, explosive strength and cardio-vascular endurance are associated with higher performance in boxing event and it should be taken into considerations especially for the achievements of junior boxers. The present findings may, therefore, be important based line information for coaches, players and sports planners. The same findings may also helpful to predict the potential factors among the promising boxers for the achievement of their performance level.

VI. Practical Application

The results of the research can be used in the state and national team selection and it can also be utilised in the selection process of young boxers in striving towards the success of high level boxing competition.

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