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Research Article

FORMULATION OF FRAMEWORK FOR SPORTS TALENT IDENTIFICATION

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ABSTRACT

The objective of the study is to develop a Sports Identification and ranking Framework and a comparison of human performance attributes in prepubertal age and puberty.

The subjects of this nonrandomized, cross-sectional study with a sample size of 2477 were divided based on location confined to Karnataka state in India of which males were 1905 and females were 572. The protocol that was used in the assessment was the NAMSLA which is abbreviated as the following non-fatiguing tests, agility tests, maximum muscle strength and maximum muscle power tests, speed tests, local Muscular endurance tests, and an aerobic test.

There was a statistically significant difference between both the groups in the following components Non at a significance level of < 0.05. However, body mass index (BMI), visceral fat, bone mass, protein and speed were insignificant.

Sports Talent Identification and ranking framework would help the researcher and sports scientists to create a talent pool and groom them to attain podium place in national and international events.

INTRODUCTION

The practice of identifying current participants who have the potential to flourish in a specific sport is known as talent identification (TID) (Russell, 1989). The recognition of an exceptional quality natural endowment or ability is a core definition of talent identification. However, identifying a gifted athlete within a sport is a multidimensional and difficult task. In sports, talent is defined by attributes that are at least partially genetically determined, are influenced by a variety of external factors, and are difficult to precisely assess ((Elliott, Ackland, Blanksby, Hood, & Bloomfield, 1989)). Moreover, adolescent talent is identified by a combination of intrinsic ability, early evidence of adult play patterns, and demonstrations of highly sports-specific capabilities (Howe, Davidson, & Sloboda, 1998).

Young athletes with the potential to succeed in senior-level sport are identified through talent identification programmes (Vaeyens, Lenoir, Williams, & Philippaerts, 2008) . TID programmes have gained in popularity in recent years and are now viewed as vital outlets for athletes to optimise their potential for success (Anshel & Lidor, 2012)(Lidor, CôTé, & Hackfort, 2009). This is especially true now that nations are under more pressure than ever to perform in sport at the international level (Anshel & Lidor, 2012). It is not typical to see countries spend millions of dollars on evidence-based strategies for gaining a competitive advantage (Hogan & Norton, 2000). It has been proposed that a successful TID programme has the potential to uncover talent early, which might be critical in improving a country's prospects of sporting success (Anshel & Lidor, 2012).

Many sports have a substantial talent identification component, and a scientific, systematic approach continues to evade recruitment officers. Initially developed in several Eastern European countries, scientific methods of talent identification involved government-sponsored, systematic, and large-scale testing of children (Claessens, 1999). The purpose of broad talent identification programmes was to funnel talented people into sports where they would be most effective. Campaigns to identify talent aren't limited to the communist countries where they began in the 1960s and 1970s. A similar ambitious initiative was carried out in Australia (Gulbin, 2013). Nine students between the ages of 14 and 16 were asked to participate in a battery of eight physiological examinations. The tests' findings paved the road for pupils with sports-specific characteristics to gain talents in sports they had never tried before (Claessens, 1999).

TID programmes, according to Anshel and Lidor (Anshel & Lidor, 2012) enhance the athlete selection process by implementing scientific proof approaches that can be fine-tuned through system monitoring and review, hence increasing the number of talented athletes at both the domestic and international levels. TID programmes, according to Durand-

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Bush and Salmela (Salmela, 2001), have the opportunity to recognize exceptional athletes early, which aids in focusing money and training options on athletes with the highest probability of success.

Many children have the potential to perform well in sports, however, the pathway to enhance performance and maintenance of performance, in the long run, is not known to children and their parents (Vaeyens, Lenoir, Williams, & Philippaerts, 2008). Recently Sports Talent identifications have gained awareness and popularity in the last few years among parents, sports science researchers and governing bodies as well. Hence it is important to diversify the sports talent identification across the country (Vaeyens, Lenoir, Williams, & Philippaerts, 2008). But there remains a lack of understanding about how talent should be defined or identified and quantified concerning age, gender and type of sports involved. Furthermore, there is a need for translation of the assessment into performance or showing the performance potential. Hence this research is to cover the entire range of parameters of the sports with the quality and quantity of the athletes being tested. The parameters include non-fatiguing tests like the body composition and flexibility and other parameters like strength, power, agility, cardiovascular & local muscular endurance.

With these parameters into consideration, it would be easier to identify the prospective and potential athletes among different parameters and channelize them into a particular sport based on their performance across all the assessments and their performance in individual parameters. With this model, there is a better opportunity to translate their assessment into a performance-oriented scenario soon.

This article is to provide a substantial framework for talent identification and grooming in context with the Indian Population and also discuss some of the challenges at the grass-root levels. The current article is structured around the following theme:

1. The study aims to develop a Sports Identification Framework.
2. The study aims to develop a ranking system to identify talents at the grass-root level.
3. The testing of the following hypothesis:

- We hypothesized that there is a significant difference between non-fatigue test attributes in both groups (pre-puberty and puberty).
- We hypothesized that there is a significant difference between agility in both groups (pre-puberty and puberty).
- We hypothesized that there is a significant difference between maximum muscle strength and maximum muscle power attributes in both groups (pre-puberty and puberty).
- We hypothesized that there is a significant difference between the speed in both groups (pre-puberty and puberty).
- We hypothesized that there is a significant difference between local muscle endurance test attributes in both groups (pre-puberty and puberty).
- We hypothesized that there is a significant difference between aerobic tests in both groups (pre-puberty and puberty).

MATERIALS AND METHODS

Methods

The subjects of this nonrandomized, cross-sectional study with a sample size of 2477 were divided based on location confined to Karnataka state in India of which males were 1905 and females were 572. This study was completed at the Centre for Sports Science, Government of Karnataka, with data collection between December 2020 and September 2021.

Participants were recruited from different districts of Karnataka. The inclusion criteria were: age in between 8 years to 20 years and suffering from no injuries or pain or suffering from any deformities and exclusion criteria of the study was suffering from any ailment or injury. The participants were divided into two groups (pre-puberty and puberty) depending upon puberty hit to do further analysis. In context with our study, we have bifurcated the puberty at a cut off age of 12 years as in research from around the world, including India, the mean/median age of menarche ranged from 12 to 13.4 years (Biro, *et al*., 2006)(Hasemeier, 1997)(Juul, *et al*., 2006)(Ma, *et al*., 2009)(Rao, Joshi, & Kanade, 1998)(Wu, Mendola, & Buck, 2002) and Surana *et al*., 2017 concludes that in Indian boys, gonadarche and pubarche occurred at the ages of 10.41 and 13.6 years, respectively (Surana, *et al*., 2017).

Table 1: The protocol that was used in the assessment was the NAMSLA as follow:

Statistical Analysis

All data were analysed using MS Excel and Python 3.7. The normality of the data was assessed using the Kolmogorov-Smirnov test. Descriptive statistics were calculated and Mann and Whitney U test was used to compare means in both the groups for the NAMSLA attributes. The ranking was done through a Z-score and a summation of the total score was calculated.

RESULTS

Descriptive Statistics

Table 2: The mean, standard deviation, median and interquartile range of demographic characteristics, non-fatiguing tests, agility tests, maximum muscle strength and maximum muscle power tests, speed tests, local Muscular endurance test, and an aerobic test are presented below:

Table 3: Normality Test: Kolmogorov-Smirnov test was used to check the normality of the data.

Comparison between both the Group

Table 4: Comparison between both the group pre-puberty (n = 909) and post-puberty (n = 1568) through Mann Whitney U Test

So, it can be stated that in both groups there was a statistically significant difference between both the groups in the following components Non at a significance level of < 0.05. However, body mass index (BMI), visceral fat, bone mass, protein and speed were insignificant.

Table 1 Description of NAMSLA

Component	Test/Principle
Non-Fatiguing tests	**Body Composition Analysis:** BIA stands for Bioelectrical Impedance Analysis [BIA]. It is a non-invasive, simple and quick technique for measuring body composition (Glaab, 2011) and used to determine body composition across a wide range of populations, which includes athletes (Franssen, *et al*., 2014), obese individuals (Moon, 2013) (Scharfetter, *et al*., 2001), sedentary individuals and recreational athletes. The principle of the BIA is that the different tissues of the body will act as semiconductors, conductors and insulators. Large quantities of water are contained in the lean tissues and hence they are highly conductive when compared to bones and fat [adipose] tissues which have contrasting characteristics & hence they are poor conductors (Franssen, *et al*., 2014). **Flexibility** **Back Scratch:** The back-scratch test was performed to assess the upper limb flexibility. The material which is required is a measuring tape. The procedure of the test is that the participant stood and performed the test, he/she placed his/her right hand behind the head and back over the shoulder and reached down the middle of his/her back as far as possible with the fingers extended and pointing downwards. The participant placed the left hand behind their back with the palm facing outwards and fingers extended and pointing upwards. A tester aligned the middle fingers so that the distance between the middle fingers could be measured; it was considered for the right side. The procedure was repeated on the left side (LIPPINCOTT, 2010). **Sit and Reach:** The sit and reach test was used to check lower back and hamstring flexibility. The equipment required is a ruler. The testing procedure required the participant to sit on the floor with the head and back against the wall, legs fully extended. The participants placed their hands on top of each other and moved the hand over the ruler while bending forward. The distance from the baseline or zero was measured (LIPPINCOTT, 2010).
Agility Tests	**The T-test** was used to measure the four-directional agility and body control of an individual. The equipment required is 4 cones, a stopwatch and a flat surface. The testing procedure was that the participants warmed up before the test. The test was explained and demonstrated by the researcher. The participant was instructed that he/she should always face forward direction and should not cross their legs while shuffling between the cones. 3 cones were set in a straight line 5 meters apart and the fourth cone was placed 10 meters away from the middle cone of the three cones so that all the 4 cones together form a 'T' shape. The participant started from the fourth cone, at the base of the 'T'. The participant starts from the 4th cone to the middle and touches the cone, then does side shuffles for 5 meters to the left cone and touches the left cone. After touching the left cone, the participant again side shuffled 10 meters to the far right to touch the far-right cone. The participant again shuffled 5 meters to the middle cone from the right cone and touched the middle cone. The participant then ran back to the fourth cone at the base of the 'T' and touched that cone to complete it and timing was noted (Semenick, 1990).
Maximum muscle strength &maximum muscle power tests:	**Back leg Chest:** A Back leg chest dynamometer was used to check the strength. The participants were made to stand on the dynamometer platform. The needle of the back leg chest dynamometer was kept at 0 kg. The participant was asked to stand holding the handle of the dynamometer with a semi-flexed knee, straight elbows and chest out position. They were then asked to pull with maximum force. The maximum strength was noted in Kilograms (Plasqui, 2016). **Handgrip strength:** Handgrip strength was used to check the upper limb strength. The material required is a Hand Grip Dynamometer. The testing procedure was that the participant stood with the legs shoulder-width apart. The testing position was in 90-degree shoulder flexion. The subject was asked to grip the dynamometer in the testing limb and press it and hold it for 3 seconds at the maximal strength achieved. The readings were taken for the left and the right side (Reis &Arantes, 2011). **Standing broad jump**: The participants were made to perform broad jumps to measure the lower limb power. The material required is a broad jump mat, the testing procedure is that the participant stands on the broad jump mat with the foot mark. He/she was asked to do a countermovement with arm swing and jump as far as possible and to land on both their feet. The measure on the broad jump mat at the heels of the participant on correct landing was measured and noted (Koch, *et al*., 2003). **Medicine ball Throw:** Chest throw was performed to measure the upper limb power. The material required is a medicine ball (2%-5% of the participant's body weight) and measuring tape. The testing procedure is that the participants performed the test in a seated position with legs extended their back in contact with the wall while performing the test. They were instructed to not lose contact with the wall. The tape should be aligned with the toes and should mark the starting line. The participant then threw the ball at 45° as far as they could without losing contact with the wall. The distance from the starting line to the centre of the ball where it landed was measured (Beckham, *et al*., 2019).
Speed Tests	The 50-meter track was marked. The participants were asked to sprint at the prompt of "start". The timing was noted when they crossed the finish line (Zagatto, Beck, &Gobatto, 2009).
Local Muscular endurance test	**Push-ups:** The participants were asked to perform push-ups for 1 minute to check the upper body endurance. The materials required are a flat surface, mat, metronome, and stopwatch. The testing procedure is that a proper warm-up was done and the test was demonstrated to the participant. For the push-ups, the hands were placed shoulder-width apart. The elbows were folded to 90° while going down and fully extended while coming up. Modified push-ups were performed for the females. Timer for 1 minute was started at the command of "start". The number of push-ups performed in proper form during the 1-minute time was noted (Baumgartner, Oh, Chung, & Hales, 2002). **Squats:** The participants were asked to perform squats for 1 minute. The materials required are a flat surface, chair, metronome and stopwatch. The testing procedure is that a proper warm-up was done and the test was demonstrated to the participant. For the squats, the participants were instructed to keep the feet shoulder-width apart. They were instructed to ensure that their knees did not cross their toes while squatting and their knees did not collapse inwards. A chair was kept behind the participant and they were instructed to go down to the chair level. A metronome was played at 60 beats per minute. At every other beat, the participant squatted and came up. Timer for 1 minute was started at the command of "start". The number of squats performed in proper form during the 1-minute time was noted (LIPPINCOTT, 2010). **Sit-ups:** The participants were asked to perform sit-ups for the maximum time in the proper form. The materials required are a flat surface, mat and stopwatch. The Testing procedure is that the participants were asked to lie on the mat with the knees bent, feet flat on the floor and the arms folded across the chest. They were instructed to start each sit up with their back on the floor. They had to raise themselves to the 90-degree position and then return to the floor. The feet of the participants could be held by a partner. The number of sit-ups completed in 30 seconds was recorded (Bianco, *et al*., 2015).
Aerobic test	The Yo-Yo Intermittent Recovery test was used to measure the cardiovascular endurance / aerobic parameter of the participants. The Yo-Yo intermittent recovery test was performed on a 20 m track. The participants ran repeatedly for two laps on the 20 m track back and forth between the start and the finish line. The speed of running was controlled by audio beeps and the speed kept increasing progressively. Between each 2, 20m running bout the participants had 10s active rest periods, which consisted of 2, 5 m of jogging. The test was stopped when the participants failed to reach the finish line in time. The level reached is recorded (Krustrup, *et al*., 2003).

Ranking

Most ranking systems can be classified into one of two categories: predicted or earned rankings.

The purpose of an earned ranking is to rate the participants based on the traits they were tested on to provide a way for selecting a champion or a group of teams to compete in an event, or to precisely locate a talent.

Table 2 The mean, standard deviation, median and interquartile range of demographic characteristics, non-fatiguing tests, agility tests, maximum muscle strength and maximum muscle power tests, speed tests, local Muscular endurance test, and an aerobic test are presented below:

Components	Attributes	Descriptive Statistics											
		Total (n =2477)				Pre - Puberty (n =909)				Post - Puberty (n =1568)			
		Mean	SD	Median	IQR	Mean	SD	Median	IQR	Mean	SD	Median	IQR
Non Fatiguing tests (Body composition and Flexibility)	BMI (in kg/m2)	17.46	3.4	16.8	4	17.64	3.53	16.9	4.3	17.36	3.32	16.6	3.9
	Body Fat %	17.72	7.12	16.56	9.7	19.49	7.51	18.48	11.44	16.7	6.68	15.75	8.71
	Subcutaneous Fat %	16.93	6.83	15.78	9.31	18.66	7.18	17.78	11.09	15.92	6.41	14.96	8.47
	Visceral Fat %	2	2.05	1	1	2.14	2.19	1	1	1.92	1.96	1	1
	Body Water %	56.84	6.78	58.4	8.8	55.08	7.21	56.6	11.5	57.87	6.29	59.2	7.7
	Fat Free mass (in kg)	20.42	6.6	18.8	2.9	18.92	4.9	18.4	3.3	21.29	7.27	19	2.8
	Bone Mass	1.79	1.55	1.63	0.66	1.83	1.83	1.63	0.66	1.77	1.36	1.63	0.64
	RMR	1071.4	168.35	1033	263	1058.39	164.81	1015	256	1078.95	169.97	1044	266.25
	Lower limb flexibility (in cm)	2.5	6.2	2	7	3.43	5.84	3	7	1.97	6.35	2	7
	Upper limb Flexibility Right (in cm)	6.13	5.57	6	7.3	4.82	5.09	4	6	6.89	5.7	7	7
	Upper limb Flexibility left (in cm)	7.44	5.61	7	7.8	5.75	5.21	4.8	7	8.42	5.6	8	7
Agility tests (T-test)	Agility (in seconds)	14.85	2.85	14.5	4.3	15.34	3.08	15.04	4.9	14.57	2.67	14.2	4.15
Maximum muscle strength and maximum muscle power tests (Back leg Chest, Handgrip strength, Standing broad jump, Medicine ball Throw,)	Lower Limb Strength (in kg)	59.84	29.19	55	38	55.76	26.62	51	34	62.2	30.33	60	40
	Grip Strength R (in kg)	9.58	8.59	8	8	8.97	7.98	8	10	9.93	8.91	8	8
	Grip Strength L (in kg)	8.91	8.47	8	8	8.23	7.87	8	10	9.3	8.78	8	8
	Upper Limb Power	3.72	1.45	3.5	1.7	3.35	1.28	3.1	1.85	3.93	1.5	3.6	1.65
	Lower limb Power	4.72	1.11	4.6	1.6	4.57	1.11	4.4	1.4	4.81	1.09	4.8	1.6
Speed tests (50 m sprints)	Speed	8.53	1.37	8.6	1.7	8.59	1.48	8.6	2	8.49	1.3	8.6	1.6
Local Muscular endurance test (Push-ups, Squats, Sit-ups)	Lower limb Endurance	22.19	16.76	16	14	19.94	12.33	17	8	23.49	18.74	15	26.25
	Core Endurance	25.22	12.56	22	16	21.54	12.26	18	13	27.35	12.23	25	15
	Upper limb Endurance	20.54	20.08	13	15	23.04	20.8	16	18	19.09	19.52	12	12
Aerobic test (Yo-Yo intermittent recovery test)	Cardiovascular endurance	11.98	1.32	12.1	2	11.67	1.29	11.2	1.1	12.16	1.31	12.2	2.1

Table 3 Normality Test: Kolmogorov-Smirnov test was used to check the normality of the data.

Components	Attributes	T-Statistics	P-value
Non Fatiguing Tests (Body Composition And Flexibility)	BMI	0.99	<0.05
	Body Fat	0.99	<0.05
	Subcutaneous Fat	0.99	<0.05
	Visceral Fat	0.99	<0.05
	Body Water	0.99	<0.05
	Fat-Free mass	0.99	<0.05
	Bone Mass	0.99	<0.05
	RMR	0.99	<0.05
	Lower limb flexibility	0.545	<0.05
	Upper limb Flexibility Right	0.81	<0.05
	Upper limb Flexibility left	0.866	<0.05
Agility Tests (T-TEST)	Agility	0.99	<0.05
Maximum Muscle Strength And Maximum Muscle Power Tests (Back Leg Chest, Handgrip Strength, Standing Broad Jump, Medicine Ball Throw,)	Lower Limb Strength	0.99	<0.05
	Grip Strength R	0.86	<0.05
	Grip Strength L	0.85	<0.05
	Upper Limb Power	0.93	<0.05
	Lower limb Power	0.99	<0.05
Speed Tests (50 M Sprints)	Speed	0.99	<0.05
Local Muscular Endurance Test (Push-Ups, Squats, Sit-Ups)	Lower limb Endurance	0.98	<0.05
	Core Endurance	0.99	<0.05
	Upper limb Endurance	0.97	<0.05
Aerobic Test (Yo-Yo Intermittent Recovery Test)	Cardiovascular Endurance	0.99	<0.05

On the other hand, the purpose of a predictive ranking method is to provide the most accurate prediction of the outcome of a future event involving two teams or participants.

NAMSLA framework was designed to collect the data, these data were further drilled down to give ranking to the participants. Ranking approach:

1. The mean of each attribute was calculated of the whole sample individually.

   $\mu = \sum_{i=1}^{N} \frac{Xi}{N}$ **equation….1**

2. The standard Deviation of each attribute was calculated for the whole sample individually.

   $\sigma = \sqrt{\sum_{i=1}^{n} \frac{X-\bar{X}}{n-1}}$ **equation….2**

3. Z – score of each attribute of the whole sample was calculated individually for all participants.

   $z = \frac{x-\mu}{\sigma}$ **equation…. 3**

4. Summation of each attribute was executed for individual participants

   $total\ score = \sum z$ **equation…. 3**

5. Comparison of the whole sample was done to each participant and rank was allotted.

Table 4 Comparison between both the group pre-puberty (n = 909) and post-puberty (n = 1568) through Mann Whitney U Test

Components	Attributes	T-Statistics	P-Value
Non Fatiguing Tests (Body Composition And Flexibility)	BMI	745365	0.06
	Body Fat	867348	<0.01*
	Fat Free Weight	645674	<0.01*
	Subcutaneous Fat	872457	<0.01*
	Visceral Fat	744465	0.06
	Body Water	549079	<0.01
	Skeletal Muscle	542932	<0.01
	Lean mass	553327	<0.01
	Bone Mass	692898	0.25
	Protein	729093	0.34
	BMR	654446	<0.01
	Lower limb flexibility	806649	<0.01
	Upper limb Flexibility Right	536175	<0.01
	Upper limb Flexibility left	497875	<0.01
Agility Tests (T-Test)	Agility	812347	<0.01
Maximum Muscle Strength And Maximum Muscle Power Tests (Back Leg Chest, Handgrip Strength, Standing Broad Jump, Medicine Ball Throw,)	Lower Limb Strength	622363	<0.01
	Grip Strength R	662231	<0.01
	Grip Strength L	659238	<0.01
	Upper Limb Power	550640	<0.01
	Lower limb Power	612069	<0.01
Speed Tests (50 M Sprints)	Speed	723140	0.54
Local Muscular Endurance Test (Push-Ups, Squats, Sit-Ups)	Lower limb Endurance	752708	<0.05
	Core Endurance	482152	<0.01
	Upper limb Endurance	836416	<0.01
Aerobic Test (Yo-Yo Intermittent Recovery Test)	Cardiovascular Endurance	558138	<0.01

Table 5 The ranking of the top 10 and bottom 10 participants comprises of both raw score, standardized score and ranking.

5.a) Raw score Top 10

Age	Gender	Lower Limb Flexibility Raw	Upper Limb Flexibility Right Raw	Upper Limb Flexibility Left Raw	Lower Limb Strength Raw	Grip Strength R Raw	Grip Strength L Raw	Lower Limb Endurance Raw	Core Endurance Raw	Upper Limb Endurance Raw	Upper Limb Power Raw	Lower Limb Power Raw	Speed Raw	Cardio Raw	Agility Raw
16	Male	21	12.5	15	55	59	56	16	26	11	3.75	6.8	4.5	14.5	14.6
16	Male	15	4	0.5	133	96	84	22	18	24	1.9	3.8	5.02	12.2	13.79
17	Male	14	6	6	130	75	64	25	13	20	1.9	6.7	4.8	14.1	16.55
15	Male	14	1	2.5	118	69	59	20	15	20	2.2	7.4	4.2	12.2	15
14	Male	15	13	15	80	14	20	61	34	71	4.1	7	7.1	13.3	13.05
15	Male	13.5	13	13	135	26	24	60	37	25	4.3	6.1	7.3	12.3	12
17	Male	2	12	12.5	128	59	55	20	18	22	1.9	4.1	4.9	13.2	14.35
11	Male	14	8	5	150	30	38	18	21	23	6	7	7.4	14.2	14.3
10	Male	14	8	5	150	30	38	18	21	23	6	7	7.4	14.2	14.3
13	Male	6.5	16	9	140	16	30	20	40	60	2.7	6.8	7.5	14.2	12.05

5.b) Standardize Score with Top 10 Ranking

Lower Limb Flexibility Standardize	Upper Limb Flexibility Right Standardize	Upper Limb Flexibility Left Standardize	Lower Limb Strength Standardize	Grip Strength R Standardize	Grip Strength L Standardize	Lower Limb Endurance Standardize	Core Endurance Standardize	Upper Limb Endurance Standardize	Upper Limb Power Standardize	Lower Limb Power Standardize	Speed Standardize	Cardio Standardize	Agility Standardize	Total Score	Ranking
2.9816	1.142445	1.34801	-0.16572	5.751662	5.557394	-0.36905	0.062399	-0.47508	0.021073	1.878996	2.94677	1.902339	0.089113	22.67196	1
2.014421	-0.38277	-1.23808	2.506879	10.05766	8.861881	-0.01108	-0.57464	0.172263	-1.25506	-0.83394	2.566371	0.165844	0.373603	22.42334	2
1.853225	-0.0239	-0.25715	2.404086	7.613714	6.501533	0.167904	-0.97279	-0.02692	-1.25506	1.788565	2.727309	1.60034	-0.59577	21.52509	3
1.853225	-0.92109	-0.88138	1.992918	6.915444	5.911446	-0.1304	-0.81353	-0.02692	-1.04812	2.421584	3.166231	0.165844	-0.05138	18.55388	4
2.014421	1.232164	1.34801	0.690883	0.51464	1.308768	2.315702	0.699436	2.512645	0.262503	2.059859	1.044775	0.996341	0.633507	17.63366	5
1.772627	1.232164	0.991307	2.575407	1.911179	1.780838	2.256041	0.938325	0.222059	0.400463	1.245977	0.898467	0.241343	1.002291	17.46849	6
-0.08113	1.052727	0.902132	2.335558	5.751662	5.439377	-0.1304	-0.57464	0.072673	-1.25506	-0.56265	2.654155	0.920841	0.176918	16.70216	7
1.853225	0.334977	-0.4355	3.089368	2.376692	3.433081	-0.24972	-0.33575	0.122468	1.573123	2.059859	0.825313	1.675839	0.19448	16.51745	8
1.853225	0.334977	-0.4355	3.089368	2.376692	3.433081	-0.24972	-0.33575	0.122468	1.573123	2.059859	0.825313	1.675839	0.19448	16.51745	8
0.644252	1.770477	0.277902	2.746727	0.747397	2.488942	-0.1304	1.177214	1.964896	-0.70322	1.878996	0.75216	1.675839	0.98473	16.27591	10

5.c) Raw score Bottom 10

Age	Gender	Lower Limb Flexibility Raw	Upper Limb Flexibility Right Raw	Upper Limb Flexibility Left Raw	Lower Limb Strength Raw	Grip Strength R Raw	Grip Strength L Raw	Lower Limb Endurance Raw	Core Endurance Raw	Upper Limb Endurance Raw	Upper Limb Power Raw	Lower Limb Power Raw	Speed Raw	Cardio Raw	Agility Raw
12	Male	-4	0	2	15	0	0	24	16	17	1.6	2.8	8.6	12.2	23.7
11	Male	-4	0	2	15	0	0	24	16	17	1.6	2.8	8.6	12.2	23.7
9	Male	-2	4	4	25	2	2	22	6	42	2	3	13	11.2	21.8
12	Male	12	1	2	20	0	0	16	7	7	1.8	3	11.5	11.1	21.6
8	Male	2	1	3	20	0	0	13	8	6	1.4	2.2	12.5	11.1	12.3
12	Male	2	0	0	15	0	0	16	13	5	1.7	3	7.9	9.1	19.4
11	Male	4	0	0	23	0	0	16	7	6	1.5	4.2	7.5	9.1	23.7
12	Male	0	-5	0	5	4	2	10	12	4	1.6	3.8	11	9.1	12.1
10	Female	-12	-2	2	35	8	4	10	12	12	2.9	3	13	11.1	16.4
9	Male	-2	0	0	33	0	0	14	12	7	1.3	2	11.8	11.1	21.4

5.d) Standardize Score with Bottom 10 Ranking

Lower Limb Flexibility Standardize	Upper Limb Flexibility Right Standardize	Upper Limb Flexibility Left Standardize	Lower Limb Strength Standardize	Grip Strength R Standardize	Grip Strength L Standardize	Lower Limb Endurance Standardize	Core Endurance Standardize	Upper Limb Endurance Standardize	Upper Limb Power Standardize	Lower Limb Power Standardize	Speed Standardize	Cardio Standardize	Agility Standardize	Total Score	Ranking
-1.04831	-1.10052	-0.97056	-1.53628	-1.11466	-1.05158	0.108243	-0.7339	-0.1763	-1.462	-1.73826	-0.05253	0.165844	-3.10701	-13.8178	2468
-1.04831	-1.10052	-0.97056	-1.53628	-1.11466	-1.05158	0.108243	-0.7339	-0.1763	-1.462	-1.73826	-0.05253	0.165844	-3.10701	-13.8178	2468
-0.72592	-0.38277	-0.61385	-1.19364	-0.8819	-0.81554	-0.01108	-1.53019	1.06858	-1.18608	-1.55739	-3.27129	-0.58915	-2.43969	-14.1299	2470
1.530832	-0.92109	-0.97056	-1.36496	-1.11466	-1.05158	-0.36905	-1.45056	-0.67426	-1.32404	-1.55739	-2.17399	-0.66465	-2.36944	-14.4754	2471
-0.08113	-0.92109	-0.7922	-1.36496	-1.11466	-1.05158	-0.54803	-1.37094	-0.72405	-1.59996	-2.28084	-2.90552	-0.66465	0.896924	-14.5227	2472
-0.08113	-1.10052	-1.32726	-1.53628	-1.11466	-1.05158	-0.36905	-0.97279	-0.77385	-1.39302	-1.55739	0.459545	-2.17465	-1.59675	-14.5894	2473
0.241261	-1.10052	-1.32726	-1.26217	-1.11466	-1.05158	-0.36905	-1.45056	-0.72405	-1.53098	-0.47222	0.75216	-2.17465	-3.10701	-14.6913	2474
-0.40352	-1.99771	-1.32726	-1.87892	-0.64914	-0.81554	-0.72701	-1.05242	-0.82364	-1.462	-0.83394	-1.80822	-2.17465	0.967169	-14.9868	2475
-2.33788	-1.4594	-0.97056	-0.851	-0.18363	-0.57951	-0.72701	-1.05242	-0.42528	-0.56526	-1.55739	-3.27129	-0.66465	-0.54309	-15.1884	2476
-0.72592	-1.10052	-1.32726	-0.91953	-1.11466	-1.05158	-0.48837	-1.05242	-0.67426	-1.66894	-2.46171	-2.39345	-0.66465	-2.2992	-17.9424	2477

Table 5: The ranking of the top 10 and bottom 10 participants comprises of both raw score, standardized score and ranking.
5.a) Raw score Top 10
5.b) Standardize Score with Top 10 Ranking
5.c) Raw score Bottom 10
5.d) Standardize Score with Bottom 10 Ranking

DISCUSSION

The necessity of the hour is for grassroots development across Karnataka's many districts, employing scientific techniques. Strengthening the base of the sports pyramid lays a solid basis on which the sports ecosystem may grow and have a long-term influence.

To establish and implement a system for ongoing talent evaluation and monitoring, as well as to enrol athletes in a long-term athlete development programme. As a result, a talent-spotting environment that is all-inclusive, accessible, and affordable has been created through scientific assessments. The larger the base, the better the chances of finding raw talent.

With the theme of this article, we tried to develop the framework of Sports Talent Identification NAMSLA, development of the ranking system and analysis NAMLSA in pre-puberty and post-puberty age groups.

NAMSLA

- Non-Fatiguing tests (Body composition and Flexibility)
- Agility tests (T-test)
- Maximum muscle strength and maximum muscle power tests (Back leg Chest, Handgrip strength, Standing broad jump and Medicine Ball Throw)
- Speed tests (50 m sprints)
- Local Muscular endurance test (Push-ups, Squats and Sit-ups)
- Aerobic test (Yo-Yo intermittent recovery test)

The above-mentioned tests were carried out in the particular order from 1 through 6 to ensure that the previous assessment which was carried out for the athlete will not affect the subsequent assessment to a large extent. The fundamental principle with the testing is that one test should affect the performance of another test in terms of the large variation in the assessment point of view (Baumgartner & Jackson, Measurement for evaluation in physical education and exercise science., 1998). Hence this protocol allows for optimal testing time in terms of recovery and also efficiency was maintained by the test order which was designed to require shorter recovery times between tests to provide an efficient testing session and with optimal performance (Baumgartner & Jackson, Measurement for evaluation in physical education and exercise science., 1998).

As an example, 3 to 5 minutes of recovery is required for taxing the phosphagen energy system at a maximal rate(Bogdanis, Nevill, Boobis, Lakomy, & Nevill, 1995)(Parkin, Carey, Zhao, & Febbraio, 1999) and for the recovery for the glycolytic energy system is 1 hour, when it is done at a maximal rate (Buchheit & Laursen, 2013). Hence, tests such as agility tests were administered before the above-mentioned tests as they produce less fatigue than those are likely to produce fatigue and confound the results of subsequent tests.

The test assessments were well organised, where the athletes were told about the purpose and procedures of the testing, which also contributes to the reliability of the test scores. The only limitation was the time constraint and the group of athletes were in large numbers. However, efficiency was maintained by employing duplicate test setups. For example, when one is conducting the 50-meter sprint, two test courses were set up (Baumgartner & Jackson, Measurement for evaluation in physical education and exercise science., 1998). The same was applied to other multiple testing batteries and also ensured that the assessment quality was not compromised.

All the tests were administered on the same day, ensuring that there was sufficient recovery in between the tests and especially the aerobic test which Yo-Yo intermittent recovery test was administered at last as mentioned above after an extended period of rest (Baumgartner & Jackson, Measurement for evaluation in physical education and exercise science., 1998). The assessments were administered at the same time of the day to avoid physiological fluctuations which might be due to the differences in the circadian rhythm of the athletes.

The time and date were also mentioned along with the purpose of the assessment which aided the athletes to prepare physically and mentally. In terms of reliability of the assessments, a short, supervised pre-test practice or familiarization session was done, prior to the beginning of the assessments (Kang, 2015). A brief warm-up before testing improves the reliability (Baumgartner & Jackson, Measurement for evaluation in physical education and exercise science., 1998) and hence organized warm-up consists of a general warm-up and dynamic stretching was included before the commencement of the assessment. Reliability is a degree of consistency that should be maintained all the time. Reliability has many variables which could hamper the assessment scores such as (Baumgartner & Jackson, Measurement for evaluation in physical education and exercise science., 1998):

- Lack of Interrater reliability
- Typical error of measurement
- Intra-rater reliability

To avoid the lack of interrater reliability, 1 rater/tester/evaluator was used along with the equipment used for the assessment. The equipment which was taken for the talent identification (TID) were checked priorly and were in perfect working condition which also ruled out the possibility of a Typical error of measurement else might cause equipment error. Lack of Interrater reliability is the degree to which different raters agree in their test results either once or when the test is repeated multiple times which ultimately is the measure of consistency. Hence to get an accurate measure of improvement, the same tester was used for a particular assessment on all days of the TID programme.

To avoid the Intra-rater reliability which is the lack of consistent scores given by the same tester we also used the equipment along with the tester to avoid large variation in scores of the athletes as well. To avoid such problems, accurate and consistent athletic testing was necessary.

All the tests were chosen to be specific for that particular parameter as mentioned above in the protocol of NAMSLA. The emulation of a particular test to the parameter being tested should be valid and reliable which was carried out based on the following criteria:

- Metabolic Energy System
- Training Status and Age
- Age and Sex
- Environment Conditions

The main necessity of the test is to emulate the energy requirements of the specific nature of the sport to which the test is related to and this forms the foundation of the metabolic energy systems viz., the phosphagen, glycolytic, and oxidative and the correlation between each energy system which is essentially applied through the principle of specificity during the assessments and hence the tests were also deemed to be valid (Buchheit & Laursen, 2013)(Fox & Foss, 1993)(Joyce & Lewindon, 2014)(Turner & Stewart, 2013).

The training status and age were also taken into consideration for the TID programme as it'll be inappropriate for inexperienced athletes to perform high-intensity technique-oriented tests/assessments such as the power clean, deadlift to name a few. Hence the safety and efficacy of the assessment were also taken into consideration with the help of equipment and alternative safer tests which can be performed by the young athletes without experience as well (Buchheit & Laursen, 2013).

Age and sex, both can affect the validity and reliability, for example, the 1.8 kilometres run can be a valid and reliable test for aerobic power for college-aged men and women athletes (Larsen, *et al*., 2002), but may not be for preadolescents or pre-puberty athletes possibly due to lack of interest and experience in a sustained speed of running (Pescatello, Riebe, & Thompson, 2014). Since most of the athletes were pre-adolescence and had not attained puberty yet, it was appropriate to go for an easier yet specific, reliable and valid test as mentioned in the NAMSLA protocol which was performed by the young athletes.

Environment conditions were considered while the tests were administered to the athletes during the TID program. The assessments were carried out under the roof and supervision of an experienced tester/rater/evaluator and the environmental temperature was 25°C with 57% humidity on the day of the assessments. This was taken into consideration as the combination of high temperature and high humidity can impair endurance exercise performance, which consequently can pose health risks, and lower the validity of tests such as aerobic endurance exercise tests. This is an imminent factor especially for aerobic endurance performance (Parkin, Carey, Zhao, & Febbraio, 1999)(Sparks, Cable, Doran, & Maclaren, 2005) and intermittent sprint performance (Bradley, *et al*., 2014) as the scores can be impaired when the temperature approaches 26-28 °C, especially if the humidity exceeds 50% (Kraning & Gonzalez, 1997).

Ranking

Stefani (1999), suggested that in most sports, determining a ranking (from best to worst) of individual athletes or teams throughout previous competition or assessment using some metric system or algorithm to provide a numerical rating by which ranking is determined is of interest. For example, an organization might aim to select the best sprinter throughout an assessment. Therefore, measurement of each attribute of NAMSLA (except body composition as it does not contribute to assessing physical performance) would be executed and stored in a database.

In the case of Competitive event, ranking is given on the following theme, performance is judged, J (all combat sports, diving, and gymnastics), measured, M (by time, length, or weight as in bobsled, swimming, and weightlifting), or scored, S (as in baseball, tennis, and golf). A scored performance is one in which the points earned may be computed by an objective observer using a table that converts performance to points (thus removing score due to judgement). The three forms of evaluation are mutually exclusive (Stefani, 1999).

However, concerning our study we were identifying the talent, thus, the taxonomy of sports ranking could be clustered in two aspects either type of human performance test conducted or mode of evaluation, in our study we used the NAMSLA framework for human performance testing.

To evaluate the human performance data, suppose there are n participants, k types of human performance test and nd evaluation of each performance test. The data for all of the participant's i*'s* evaluated performance can be stored in a $k \times nd$ matrix Zi, in which row m is designated zm. Then, the evaluated performance for all n participants can be stored in a $nk \times nd$ matrix Z.

$$Z = \begin{matrix} Z1 \\ Z2 \\ Zn \end{matrix}$$

As discussed earlier, the ranking was given to each attribute by standardizing the data, summation of each attribute to get the total score and comparing it with the array of all the samples. The advantage of this methodology it is concise and easy.

Group Analysis: In this study, we hypothesized that there will be a significant difference between the pre-puberty and post-puberty kids in the strata concerning:

- **Non-Fatiguing tests** (Body composition and Flexibility)
- **BMI -** The value of BMI was not significant, most likely attributable to one of the following factors mentioned below:
- Overweight or obesity in childhood, but very little is known about its association with subsequent height gain in childhood and adolescence, including the timing of puberty.
- According to He *et al*., larger gain either in BMI or in height during childhood will induce the onset of early puberty(He & Karlberg, 2001).
- Hence, we could not find significance in BMI between pre and post-puberty.

Body Fat - Here we observed that the body fat value to be significant which might be attributed to a growth spurt and hormonal regulations during which the fat deposition tends to be higher for both males and females especially due to preadolescence and the initial period of adolescence as well (Taylor, Grant, Williams, & Goulding, 2010). Furthermore, girls were found to have a higher percentage of fat deposition which is due to increased deposition of peripheral fat in females.

Subcutaneous Fat - The p-value < = 0.01 was found to be significant, most likely due to the increase in leptin levels in the blood which is found have a number to be involved in regulating various endocrine mechanisms such as the onset of puberty, insulin secretion and is related to disorders including obesity and polycystic ovary syndrome (PCOS)(Siervogel, *et al*., 2003). The primary site of synthesis of leptin is the adipose tissue and is also one of the regulators of energy balance which is done by regulating with many other neuropeptides which inhibits food intake, and affects the expenditure of energy. But the accumulation of subcutaneous adipose tissue could function in improvement or protection of metabolic health when compared to the harmful effects of accumulation of visceral and hepatic fat which leads to metabolic decline over the period (Gyllenhammer, Alderete, Toledo-Corral, Weigensberg, & Goran, 2016).

Visceral Fat - The p-value is found to be insignificant, and might be possibly due to fat distribution throughout the body hormonal regulation such as oestrogen during the early pubertal period which is associated with a gynoiddistribution of body fat (Suliga, 2009) . A positive energy balance mainly as a result of low energy expenditure (Suliga, 2009) and positive energy balance does not appear to be a strong determinant of abdominal visceral fat, as is the case with other body fat phenotypes (Suliga, 2009). The accumulation of visceral fat is assumed to be similar in prepubertal boys and girls, although not all studies are consistent (Taylor, Grant, Williams, & Goulding, 2010). Furthermore, there is an influence of sexual dimorphism in fat distribution in late puberty when compared to prepuberty (Suliga, 2009). According to Suliga *et al*., the effects of the hormones during puberty might likely contribute more towards the body fat distribution, rather than the visceral fat as it is more similar to subcutaneous fat in adolescence and pre-puberty children and hence visceral fat level between pre and post-puberty were found to be insignificant(Suliga, 2009).

Fat-Free mass - Fat-Free mass also reflects significance, of p-value < = 0.01 between pre and post-puberty which can be attributed to the changes in the hormone and the growth spurt during puberty as one of the main hormones testosterone has an essential role to play in muscle growth during puberty which essentially can be influenced by multiple factors and hormone leptin is found to have its influence independently of testosterone and Fat-free mass (Demerath, *et al*., 1999), but the evidence is inconsistent.

Bone Mass - The possible reasons for having no significance in bone mass for pre and post-puberty age groups might be due to late peaking of the bone mineral density of the age group of above 15 years even though the gain of Bone mass is faster (Elhakeem, Frysz, Tilling, Tobias, & Lawlor, 2019). Ideally, the peak BMD will be attained during the attaining adulthood of 18 years. This was observed in a recent research article support and as mentioned by Elhakeem *et al*., despite faster gains in bone mineral density, older age at puberty was associated with persistently lower bone mineral density, but the exact reasons are not known(Elhakeem, Frysz, Tilling, Tobias, & Lawlor, 2019).

RMR - We observed from the table that the RMR was found to be significant with a p-value = 0.01. Which can be associated with the higher body fat percentage in post-puberty adolescents (Griffiths, Payne, Rivers, Cox, & Stunkard, 1990). Furthermore, age influences the RMR significantly and independently as well (Molnar & Schutz, 1997). As established in the above statements, pre and post-puberty values of fat-free mass and body fat were found to be significant. Moreover, during the pubertal period, the fat-free mass, body fat, gender and age change significantly, these factors also determine the RMR of a person (Molnar & Schutz, 1997). Hence, we can establish that, although puberty does not have a direct influence on RMR, through the influence of other factors mentioned above, in an indirect way.

Flexibility- These parameters were found to be significant between the pre and post-puberty children in the study due to the influence of the hormones and neural maturation in the participants who had aged more than 12 years. According to DiStefano *et al*., post-puberty males has less hip flexibility and abduction displacement and post-pubertal females demonstrated less knee flexion and lower knee extension strength when compared to pre-pubertal males and prepubertal females respectively(DiStefano, *et al*., 2015).

Agility -There was a significant difference between the agility of both groups. The difference in agility can be seen due to the completion of myelination in the post-pubertal population. The myelination increases the speed of impulse transmission and makes the reaction time and agility faster (Malina, Bouchard, & Bar-Or, 2004).

Maximum muscle strength and maximum muscle power tests (Back leg Chest, Handgrip strength, Standing broad jump and Medicine Ball Throw)

Muscle strength - A significant difference was again seen between the pubertal and the pre-pubertal population. This can be attributed to the increase in muscle mass with growth and development and neural maturation. The neuromuscular control is limited until sexual maturation as the myelination is completed around this stage (Bar-Or, 1996).

Power - The prepubertal population has a low capacity for glycolysis, because of the rate-limiting enzyme phosphofructokinase or lactate dehydrogenase. They also rely on fat oxidation for fuel during exercise, which also lowers the ability for power production. There was a significant difference in the power production in the pre and post-pubertal population, which may have resulted because of the above-mentioned reason (Santos, Welsman, Croix, & Armstrong, 2002).

Speed- No significant difference was seen between the two populations. This can be due to the lack of training in the post-pubertal population and a lack of the development and practice of fundamental motor skills.

Local Muscular endurance test (Push-ups, Squats and Sit-ups)

Muscle Endurance - A significant difference was seen in the muscle endurance of the pre and post-pubertal population. The difference can be attributed to the increase in the muscle mass of the muscles in the post-pubertal population and the oxygen consumption ability and the change in the insulin response (Malina, Bouchard, & Bar-Or, 2004).

Aerobic test (Yo-Yo intermittent recovery test) -An increase in the cardiovascular and respiratory function is seen post-puberty as there is an increase in the stroke rate, heart rate increasing the cardiac output. All these lead to an increase in the oxygen uptake capacity in the post-pubertal population. There is also an increase in the running economy because of the difference between children and adults in stride frequency for the same fixed-pace run when compared between pre and post-pubertal populations. A significant difference was seen in the result (Bar-Or, 1996).

The strength of the study is the sample size and till now, no study was done in this large sample pool to identify the talent, the inclusion of NAMSLA methodology has aided in designing the framework of Sports Talent Identification and formulation of ranking system to evaluate human performance. The limitations of the study were that we could not carry out one of the anaerobic parameters of the assessment which was a 300 yards' test, which also could have added a qualitative feature to the TID programme and, also sports specificity was not taken into the consideration for developing weightage ranking. However, future research would look into this perspective and consideration would be taken for its role in pre-puberty and pubertal adolescents and clustering of the sample could be done to deduce sports specificity.

CONCLUSION

Sports Talent Identification and ranking framework would help the researcher and sports scientists to create a talent pool and groom them to attain podium place in the national and international event. The inclusion of the human performance attributes in the NAMSLA framework would be going to help the researcher to look at player evaluation from each spectrum and diversity. The practical implication of the study is that it would help sports scientists to identify talent in a data-driven manner.

Statement of Ethics

Subjects (or their parents or guardians) gave their written informed consent. The study protocol was approved by the institute's committee on human research. No animals were used in this study.

Disclosure Statement

The authors have no conflict of interests to declare.

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Author Contributions

All of the authors contributed to this study and the preparation of this paper.

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