InterCriteria Analysis of data from intellectual and physical evaluation tests of students practicing sports activities

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Abstract: Physical activity among university students is essential for complementing sedentary behaviour and for individuals' future mental and physical health. At the same time, intellectual qualities like operative, analytic, logical thinking, attention span, short-term memory, long-term memory, etc., are important factors for the successful participation in different academic sports activities. In view of this, it is important to evaluate the initial level of intellectual and physical development by applying a group of specific tests. In this paper, we propose the application of the approach of InterCriteria Analysis (ICrA) to data, obtained from university students practicing sports activities in order to evaluate the appropriateness of the used tests.

Keywords: Physical activity, University students, InterCriteria Analysis, Intuitionistic fuzzy sets.

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1 Introduction

Physical condition and intellectual development monitoring is important for assessing health-related aspects during the life span. It is important to monitor trends in health and physical activity patterns in early adult life as this represents a period in which health behaviors get established and physical inactivity can manifest [11, 8]. The beginning of the university stage is usually

accompanied by physiological and psychological changes associated with late adolescence and emerging adulthood [9]. It should also be noted that it is an important stage of life with great changes in behaviours and responsibilities derived from emancipation and the demands developed by a new university degree [6]. Changes in the levels of physical activity during university studies may reflect disruptions in established living patterns that persist into the workforce [7]. Moreover, the promotion of university student health has been shown to enhance future wellbeing and career performance [5]. In view of this, it is important to evaluate the initial level of intellectual and physical development by applying a group of specific tests. Nevertheless, it is of great importance to evaluate the usefulness of the applied method of testing and to establish a well-structured test battery. In this paper, we propose the application of the approach of InterCriteria Analysis (ICrA) to data, obtained from university students practicing sports activities. The data was analyzed in search of correlations between the results from the method of testing for the level of development of the motive qualities, as well as tests for assessment of the psychic and personality qualities in order to predict the reliability of the proposed test battery.

2 Presentation of the input data

The investigation and the data collection process, has been carried out in the educational year 2011/12. Contingent of the investigation are 66, 1st year students (males) in UNWE, attending basketball and table tennis trainings from “Physical Culture” subject. We have chosen a set of several parameters defining the level of cognitive and emotional well-being in a test battery of 13 control tasks for intellectual status, and 5 control tasks for physical condition. These tests have been divided into two major groups, as follows:

Physical condition

- Endurance. It is the ability of an organism to exert itself and remain active for a long period of time (C1),
- Grip strength. It is the force applied by the hand to pull on or suspend from objects and is a specific part of hand strength (C2),
- Agility. It is the ability to change the body's position efficiently, and requires the integration of isolated movement skills (C3),
- Balance. It is an ability to maintain the line of gravity (vertical line from center of mass) of a body within the base of support with minimal postural sway (C4),
- Skillfulness. It is the ability to perform different tasks well (C5).

Personality

- Operational thinking. This type of thinking repeats and illustrates action, preceding or following it within a limited temporal span (C6),
- Analytical thinking. This type is a critical component of visual thinking that gives one the ability to solve problems quickly and effectively (C7),
- Logical thinking. This is the process in which one uses reasoning consistently to come to a conclusion (C8),
- Visual memory. It is a form of memory which preserves some characteristics of our senses pertaining to visual experience (C9 and C10),
- Willpower. This is the cognitive process by which an individual decides on and commits to a particular course of action (C11),

- Personal activity. The person's skill to participate actively in different activities (C12),
- Communication skills. These allows you to understand and be understood by others (C13),
- Organizational skills. Refers to our ability to stay focused on different tasks, and use your time, energy, strength, mental capacity, physical space, etc. effectively and efficiently in order to achieve the desired outcome (C14),
- Morality. It is the differentiation of intentions, decisions and actions between those that are distinguished as proper and those that are improper (C15).
- Neuroticism. It is one of the Big Five higher-order personality traits in the study of psychology. Individuals who score high on neuroticism are more likely than average to be moody and to experience such feelings as anxiety, worry, fear (C16),
- Extraversion and Introversion. Extraversion tends to be manifested in outgoing, talkative, energetic behavior, whereas introversion is manifested in more reserved and solitary behavior (C17),
- Anxiety. It is a normal emotion that causes increased alertness, fear, and physical signs, such as a rapid heart rate (C18),

The results from the tests, as an input data are obtained from two control groups of students and are listed below in Table 1 and Table 2.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
O1	122.25	10	7.49	1.8375	75.23	1.73	99.65	5	10	11	11	25	77.34	20	16	30	14	1
O2	131.78	22.6	8.88	1.575	73.89	1.50	121.35	5	10	13	8	21	55.12	20	17	28	20	10
O3	129.75	31	7.64	1.4425	60.58	1.88	101.93	6	6	8	10	21	64.97	19	18	35	17	6
O4	107.75	29.4	6.685	2.2425	67.85	2.15	106.50	7	9	9	11	24	75.51	17	19	33	18	8
O5	133.36	42.8	7.685	1.4675	55.19	2.19	111.07	6	8	9	5	17	70.65	6	6	52	13	7
O6	131	14.6	9.05	1.605	79.41	2.32	124.78	5	9	11	6	19	39.84	13	13	29	19	10
O7	112.09	19.6	7.38	1.6525	52.8	1.76	88.22	4	9	11	9	16	62.57	9	14	40	17	6
O8	131.04	27.2	9.65	2.4375	79.11	2.51	112.21	5	10	10	8	22	62.82	19	17	36	21	10
O9	128.66	23	9.19	1.09	74	2.32	104.22	6	5	10	5	14	64.33	16	13	40	16	7
O10	148.39	33.6	12.88	1.325	54.64	1.78	95.08	4	6	11	11	21	62.19	12	14	54	18	14
O11	113.94	22.2	9.015	1.2925	66.24	2.05	98.50	4	6	10	10	22	68.19	16	17	41	19	11
O12	132.66	32.4	11.485	1.2925	74.39	2.05	116.78	4	8	12	8	18	63.45	16	16	45	15	13
O13	129.15	31.8	7.915	1.38	72.89	2.58	114.50	8	8	10	3	19	52.91	15	10	46	17	3
O14	122.38	30.2	9.97	2.33	71.42	1.97	111.07	6	9	8	9	26	65.78	17	19	27	16	10
O15	127.18	26	8.175	1.7225	52.68	1.68	114.50	7	10	12	2	23	73.49	18	12	34	12	0
O16	129.57	16	8.33	1.3975	71.12	2.02	121.35	8	10	6	13	23	58.90	19	15	25	18	6
O17	159.65	29.6	11.97	1.805	92.6	1.64	97.36	3	9	7	7	20	54.93	15	19	46	21	16
O18	125.96	20.8	8.47	1.255	54.84	1.94	109.93	5	9	7	7	21	56.25	16	14	39	15	8
O19	136.89	31	8.835	1.3275	74.31	1.92	119.07	6	8	12	6	21	56.51	20	19	24	17	3
O20	124.87	26.4	7.31	1.38	64.97	1.78	90.51	3	6	8	10	19	60.67	14	11	45	15	7
O21	114.44	19.8	8.68	1.26	75.1	2.40	124.78	7	7	8	7	20	68.50	16	16	53	16	17
O22	122.25	10	7.49	1.8375	75.23	1.73	99.65	5	10	11	11	25	77.34	20	16	30	14	1
O23	131.78	22.6	8.88	1.575	73.89	1.50	121.35	5	10	13	8	21	55.12	20	17	28	20	10
O24	129.75	31	7.64	1.4425	60.58	1.88	101.93	6	6	8	10	21	64.97	19	18	35	17	6
O25	107.75	29.4	6.685	2.2425	67.85	2.15	106.50	7	9	9	11	24	75.51	17	19	33	18	8
O26	133.36	42.8	7.685	1.4675	55.19	2.19	111.07	6	8	9	5	17	70.65	6	6	52	13	7
O27	131	14.6	9.05	1.605	79.41	2.32	124.78	5	9	11	6	19	39.84	13	13	29	19	10
O28	112.09	19.6	7.38	1.6525	52.8	1.76	88.22	4	9	11	9	16	62.57	9	14	40	17	6
O29	131.04	27.2	9.65	2.4375	79.11	2.51	112.21	5	10	10	8	22	62.82	19	17	36	21	10
O30	128.66	23	9.19	1.09	74	2.32	104.22	6	5	10	5	14	64.33	16	13	40	16	7
O31	148.39	33.6	12.88	1.325	54.64	1.78	95.08	4	6	11	11	21	62.19	12	14	54	18	14
O32	113.94	22.2	9.015	1.2925	66.24	2.05	98.50	4	6	10	10	22	68.19	16	17	41	19	11
O33	132.66	32.4	11.485	1.2925	74.39	2.05	116.78	4	8	12	8	18	63.45	16	16	45	15	13

Table 1. Results from the tests (Criteria: C1-C18) of the first control group of 33 male students attending basketball (Objects: O1-O33).

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
O1	206.02	21.2	11.51	1.032	79.1	2.399	111.07	6	10	9	10	24	72.285	19	18	206.02	21.2	11.51
O2	142.44	26.4	9.925	1.185	66.81	3.219	121.35	6	8	8	7	24	61.365	16	12	142.44	26.4	9.925
O3	148.16	33.4	12.105	1.37	78.12	3.56	98.503	7	8	10	12	23	62.31	15	14	148.16	33.4	12.105
O4	139.89	28.2	9.755	1.0125	69.94	2.34	92.791	6	3	5	10	23	65.53	19	16	139.89	28.2	9.755
O5	157.09	34.4	9.995	1.1775	73.02	2.194	105.35	5	6	11	4	25	71.085	20	19	157.09	34.4	9.995
O6	171.47	20	13.25	1.22	79.08	2.803	103.07	5	10	11	8	17	55.18	11	11	171.47	20	13.25
O7	132.88	19.8	8.945	1.2075	116.09	2.216	116.78	6	6	13	12	24	56.44	19	19	132.88	19.8	8.945
O8	146.91	21.4	7.34	1.16	73.15	1.685	101.93	3	10	10	11	26	65.595	15	15	146.91	21.4	7.34
O9	146.9	32.8	10.68	1.075	78.58	1.770	112.21	6	5	9	5	21	56.06	18	13	146.9	32.8	10.68
O10	149.76	23.2	12.76	1.3275	76.51	2.276	108.78	6	10	9	1	20	77.02	15	15	149.76	23.2	12.76
O11	118.24	19.6	10.08	1.4825	117.58	1.958	120.20	6	10	9	9	18	68.495	16	14	118.24	19.6	10.08
O12	154.34	22	10.275	1.225	73.12	2.125	117.92	6	8	9	9	25	69.825	19	18	154.34	22	10.275
O13	173.42	20.2	10.24	0.975	82.43	1.9901	113.3	5	8	4	5	21	63.195	18	14	173.42	20.2	10.24
O14	163.36	17.6	9.185	1.6825	68.38	2.840	105.35	6	10	10	8	24	79.925	13	18	163.36	17.6	9.185
O15	112.24	21.4	7.99	1.275	73.48	2.006	109.92	6	7	11	6	27	69.635	14	14	112.24	21.4	7.99
O16	115.65	22.6	9.945	1.53	89.23	1.64	111.07	6	8	10	7	24	50.125	7	13	115.65	22.6	9.945
O17	198.94	17.8	13.245	1.17	83.17	2.343	111.07	4	8	8	10	27	73.045	20	17	198.94	17.8	13.245
O18	128.76	15.4	8.71	1.1825	59.01	2.44	124.7	9	10	8	10	20	59.72	15	13	128.76	15.4	8.71
O19	133.41	21	8.675	1.23	67.02	1.88	115.639	3	10	8	8	24	70.325	15	17	133.41	21	8.675
O20	178.07	20.8	9.685	0.91	84.98	2.756	104.21	6	5	10	12	26	77.465	11	7	178.07	20.8	9.685
O21	136.11	10.8	8.51	1.025	64.3	2.26	112.2	5	8	10	7	23	72.79	19	10	136.11	10.8	8.51
O22	128.37	27.2	7.925	1.3675	57.5	1.60	100.78	4	9	12	8	13	61.36	15	13	128.37	27.2	7.925
O23	177.05	20.4	10.04	1.3325	60.79	3.162	100.78	6	6	8	9	18	61.175	20	17	177.05	20.4	10.04
O24	194.75	18.6	12.915	0.865	123.61	3.26	111.070	6	3	9	11	20	63.13	19	18	194.75	18.6	12.915
O25	208.81	20.4	9.495	1.7625	77.43	1.894	104.21	6	10	13	6	22	65.655	16	16	208.81	20.4	9.495
O26	207.05	15.6	8.605	1.34	74.68	2.686	113.35	6	9	11	6	21	52.085	19	17	207.05	15.6	8.605
O27	195.21	26	12.98	0.98	73.28	1.84	99.645	2	9	4	7	22	62.06	15	16	195.21	26	12.98
O28	160.46	36.4	9.515	1.3625	74.28	2.54	96.21	5	7	6	7	22	52.65	4	10	160.46	36.4	9.515
O29	163.91	12.6	9.205	1.305	85.91	3.30	96.21	5	8	4	9	18	60.92	13	10	163.91	12.6	9.205
O30	148.1	48.4	8.235	1.4075	69.76	2.676	111.07	6	10	8	5	23	59.03	16	16	148.1	48.4	8.235
O31	124.94	16	8.215	1.4375	70.35	1.97	105.35	5	5	10	12	25	77.08	20	18	124.94	16	8.215
O32	159.12	19.6	12.085	1.6275	88.51	2.235	129.34	6	10	11	10	23	59.47	19	16	159.12	19.6	12.085
O33	206.02	21.2	11.51	1.0325	79.1	2.399	111.07	6	10	9	10	24	72.285	19	18	206.02	21.2	11.51

Table 2. Results from the tests (Criteria: C1-C18) of the first control group of 33 male students attending table tennis (Objects: O1-O33).

3 Application of the InterCriteria Analysis

The method of InterCriteria Analysis is based on intuitionistic fuzzy sets, thus rendering account of the effects of uncertainty. Originally, ICRA was been proposed in [2], and various aspects of its theoretical investigation are given in papers [1, 3, 4].

For this aim, we use the developed software for InterCriteria Analysis [10] (freely available online at: <http://intercriteria.net/software>) and feed it with the data from the two control groups of students. The complete resultant tables with InterCriteria intuitionistic fuzzy membership pairs are given on Table 3 and Table 4.

While not strictly positive consonances are detected, we see that the strongest available ones, i.e., those with smallest distance from the intuitionistic fuzzy truth $\langle 1, 0 \rangle$, are those detected between the C18 (Anxiety) – C16 (Neuroticism), C18 (Anxiety) – C3 (Agility) and C5 (Operational thinking) – C6 (Skillfulness). These pairs are formed between logically related qualities. All other pairs score intuitionistic fuzzy dissonance values and are located in to the respective zone of the IF triangle showed on Figure 1.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
C1	1	0.5508	0.6292	0.4973	0.5437	0.4955	0.4866	0.3173	0.3957	0.5472	0.3244	0.3832	0.344	0.4385	0.385	0.5276	0.5152	0.5526
C2	0.5508	1	0.59	0.5134	0.4278	0.4866	0.4759	0.4777	0.3298	0.4742	0.3939	0.4385	0.5579	0.4029	0.5062	0.5312	0.4795	0.4385
C3	0.6292	0.59	1	0.5045	0.6007	0.5258	0.5829	0.4011	0.41	0.4866	0.3779	0.4742	0.3832	0.4617	0.5294	0.508	0.5526	0.6203
C4	0.4973	0.5134	0.5045	1	0.4706	0.4938	0.4902	0.4242	0.5365	0.3993	0.5223	0.5847	0.4831	0.492	0.4884	0.4474	0.4759	0.4706
C5	0.5437	0.4278	0.6007	0.4706	1	0.6132	0.5651	0.4171	0.4492	0.3815	0.4225	0.5419	0.4439	0.5241	0.4635	0.4563	0.4563	0.5276
C6	0.4955	0.4866	0.5258	0.4938	0.6132	1	0.5775	0.4866	0.4082	0.3636	0.3672	0.3957	0.4777	0.4225	0.344	0.5936	0.4724	0.5847
C7	0.4866	0.4759	0.5829	0.4902	0.5651	0.5775	1	0.5811	0.4955	0.4225	0.3262	0.4848	0.3975	0.5704	0.467	0.3512	0.4367	0.4617
C8	0.3173	0.4777	0.4011	0.4242	0.4171	0.4866	0.5811	1	0.4278	0.3619	0.3298	0.4545	0.4955	0.4171	0.4082	0.2816	0.3529	0.2353
C9	0.3957	0.3298	0.41	0.5365	0.4492	0.4082	0.4955	0.4278	1	0.4296	0.3922	0.4474	0.3743	0.4456	0.426	0.2852	0.4332	0.4029
C10	0.5472	0.4742	0.4866	0.3993	0.3815	0.3636	0.4225	0.3619	0.4296	1	0.3155	0.3547	0.4706	0.3761	0.4296	0.3547	0.4403	0.3583
C11	0.3244	0.3939	0.3779	0.5223	0.4225	0.3672	0.3262	0.3298	0.3922	0.3155	1	0.6078	0.533	0.4439	0.5027	0.3797	0.3886	0.4403
C12	0.3832	0.4385	0.4742	0.5847	0.5419	0.3957	0.4848	0.4545	0.4474	0.3547	0.6078	1	0.5633	0.5758	0.5686	0.2941	0.3583	0.3547
C13	0.344	0.5579	0.3832	0.4831	0.4439	0.4777	0.3975	0.4955	0.3743	0.4706	0.533	0.5633	1	0.4474	0.5223	0.4831	0.3298	0.3957
C14	0.4385	0.4029	0.4617	0.492	0.5241	0.4225	0.5704	0.4171	0.4456	0.3761	0.4439	0.5758	0.4474	1	0.59	0.2656	0.4617	0.3494
C15	0.385	0.5062	0.5294	0.4884	0.4635	0.344	0.467	0.4082	0.426	0.4296	0.5027	0.5686	0.5223	0.59	1	0.2906	0.5312	0.4528
C16	0.5276	0.5312	0.508	0.4474	0.4563	0.5936	0.3512	0.2816	0.2852	0.3547	0.3797	0.2941	0.4831	0.2656	0.2906	1	0.4403	0.6435
C17	0.5152	0.4795	0.5526	0.4759	0.4563	0.4724	0.4367	0.3529	0.4332	0.4403	0.3886	0.3583	0.3298	0.4617	0.5312	0.4403	1	0.5579
C18	0.5526	0.4385	0.6203	0.4706	0.5276	0.5847	0.4617	0.2353	0.4029	0.3583	0.4403	0.3547	0.3957	0.3494	0.4528	0.6435	0.5579	1

Table 3. Results of the application of the InterCriteria Analysis on the aggregated data from Table 1, IF membership parts

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
C1	1	0.4597	0.6653	0.4194	0.5968	0.6391	0.4073	0.2944	0.4294	0.3931	0.4415	0.4093	0.5181	0.4819	0.5222	0.3871	0.4839	0.4415
C2	0.4597	1	0.5242	0.506	0.4153	0.4214	0.3649	0.3306	0.3629	0.3972	0.3407	0.4919	0.4335	0.369	0.4234	0.5383	0.5524	0.6008
C3	0.6653	0.5242	1	0.4194	0.6573	0.5827	0.494	0.3649	0.3931	0.3569	0.4677	0.3831	0.494	0.4738	0.4879	0.3569	0.4859	0.4133
C4	0.4194	0.506	0.4194	1	0.4718	0.4778	0.4738	0.3911	0.5423	0.5544	0.4093	0.4274	0.4375	0.375	0.4778	0.506	0.3226	0.4234
C5	0.5968	0.4153	0.6573	0.4718	1	0.502	0.5202	0.3629	0.375	0.4698	0.5141	0.4516	0.4496	0.4153	0.4415	0.4738	0.4556	0.5
C6	0.6391	0.4214	0.5827	0.4778	0.502	1	0.4375	0.4476	0.3649	0.3589	0.5323	0.3952	0.5081	0.4435	0.4516	0.4173	0.3891	0.3508
C7	0.4073	0.3649	0.494	0.4738	0.5202	0.4375	1	0.4274	0.4778	0.4375	0.4194	0.4778	0.4657	0.5181	0.502	0.369	0.4758	0.3246
C8	0.2944	0.3306	0.3649	0.3911	0.3629	0.4476	0.4274	1	0.3024	0.3831	0.3528	0.3105	0.2802	0.3468	0.3427	0.2621	0.3246	0.2359
C9	0.4294	0.3629	0.3931	0.5423	0.375	0.3649	0.4778	0.3024	1	0.4113	0.3448	0.3206	0.4032	0.2903	0.3851	0.3387	0.3286	0.3165
C10	0.3931	0.3972	0.3569	0.5544	0.4698	0.3589	0.4375	0.3831	0.4113	1	0.4355	0.4698	0.4496	0.4073	0.4738	0.496	0.371	0.4052
C11	0.4415	0.3407	0.4677	0.4093	0.5141	0.5323	0.4194	0.3528	0.3448	0.4355	1	0.5181	0.498	0.4476	0.4718	0.4415	0.3407	0.3911
C12	0.4093	0.4919	0.3831	0.4274	0.4516	0.3952	0.4778	0.3105	0.3206	0.4698	0.5181	1	0.6109	0.4698	0.5423	0.504	0.4698	0.4637
C13	0.5181	0.4335	0.494	0.4375	0.4496	0.5081	0.4657	0.2802	0.4032	0.4496	0.498	0.6109	1	0.506	0.5665	0.4617	0.4718	0.4577
C14	0.4819	0.369	0.4738	0.375	0.4153	0.4435	0.5181	0.3468	0.2903	0.4073	0.4476	0.4698	0.506	1	0.6472	0.3004	0.5444	0.2399
C15	0.5222	0.4234	0.4879	0.4778	0.4415	0.4516	0.502	0.3427	0.3851	0.4738	0.4718	0.5423	0.5665	0.6472	1	0.3427	0.5706	0.3407
C16	0.3871	0.5383	0.3569	0.506	0.4738	0.4173	0.369	0.2621	0.3387	0.496	0.4415	0.504	0.4617	0.3004	0.3427	1	0.3407	0.6714
C17	0.4839	0.5524	0.4859	0.3226	0.4556	0.3891	0.4758	0.3246	0.3286	0.371	0.3407	0.4698	0.4718	0.5444	0.5706	0.3407	1	0.4819
C18	0.4415	0.6008	0.4133	0.4234	0.5	0.3508	0.3246	0.2359	0.3165	0.4052	0.3911	0.4637	0.4577	0.2399	0.3407	0.6714	0.4819	1

Table 4. Results of the application of the InterCriteria Analysis on the aggregated data from Table 2, IF membership parts

The results represented on Table 4 from the application of the InterCriteria Analysis on the aggregated data from the second control group of students are showing similar behaviour. The only difference is detected between the consonance values of C1 (Endurance) – C5 (Operational thinking). The graphical representation of the results is presented on Figure 2.

Figure 1. InterCriteria pairs between the 18 criteria (Table 3), as plotted as points (black) on the intuitionistic fuzzy interpretational triangle

Figure 2. InterCriteria pairs between the 18 criteria (Table 4), as plotted as points (black) on the intuitionistic fuzzy interpretational triangle

4 Conclusions

The study describes a new method of processing data obtained from university students practicing sports activities and the results obtained from the application of ICrA shows that the chosen tests in the test battery are very well combined to evaluate the initial level of intellectual and physical development of the students. Naturally, given the relatively small size of the considered data it is not possible to claim with absolute certainty that our interpretations are doubtlessly valid but they provide a starting point for further investigations.

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