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STUDY CONCERNING THE MONITORING OF THE LOWER LIMBS STRENGTH CHARACTERISTICS EVOLUTION IN DRY LAND TRAINING IN SWIMMERS AGED 10 - 14 YEARS

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Abstract

*Aim.*The monitoring way establishment of the lower limbs strength characteristics evolution, in dry land trainings, for the subjects of the research; highlighting the importance of the strength characteristics monitoring in dry land trainings aimed to the swimmers aged between 10 and 14 years;

*Methods.*Eight swimmers, one female and seven males, aged between 10 to 14 years, members of Elite Swimmers Association took part in this study. They have been monitored for three months while they attended to a training schedule that involved two sessions per week of dry land trainings focused on lower limb strength characteristics improvement. After each month they were tested by using the Kistler Quattro Jump force plate. The research methods that we used in order to accomplish this study were: the case study method, experiment method, testing method, specialty literature study, observation method.

*Results.*The results were collected by following the Bosco protocol provided by the Kistler force plate in order to get information about the level of the lower limbs strength characteristics evolution specific to each swimmer. The tests values were registered in tables and analyzed according to each swimmer features. These values showed that swimmers have achieved a growth path expression level of the strength characteristics, with small variations in some of the Bosco protocol trials.

*Conclusions.*Monitoring the evolution of the lower limbs strength regarded to dry land trainings represents an objective and useful mean for coaches in order to correlate the effects of dry land and specific (water) training. In the same time, this kind of training approach guides them toward their mission which is to help the swimmers to achieve effective adaptation to the specific effort that can be transformed in the ability to express a better motor behavior.

Key Words: Bosco protocol, force plate, measurement, vertical jumps

Introduction

Sports results obtained by the athletes are based on a series of structural and functional adaptations to specific components of the training process, reflected in all body organs and systems. The difference between the manner of achieving these adaptations by swimmers in comparison with other athletes specialized in other sports, is determined by the root causes which produce a series of changes with oriented addressability type of effort „requested" by the competition. It is also known that, for higher changes the body needs various stimuli that cause transition to the next level (such as quality, quantity or combined). Among the adjustments that swimmers are required, those relating to indications of force have a special character. This character is influenced by the strategy that has to be adopted so that the increase of the strength indices is achieved in an effective and objective way without collateral costs, that will not determine the damage of the other types of adaptations such as physical, technical, psychological, etc.

The lack of stable interactions between swimmer's body (i.e. between its extremities) and the aquatic environment where they act most of its work involves a deep attention that has to be paid to the way that the strength improvement is approached. In this context, the entire motor behavior and the achieved results are influenced in an objective way by the strength improvement level, by the variety of means and methods that are used (Girold et al., 2007; Aspenes et al., 2009; Morouço et al., 2011; Morouço et al., 2012).

In addition to the specific means used for strength developing in the aquatic environment, the approach of this motor ability outside the water, in dry land has an important role. This approach has become increasingly used, it represents a way through which coaches can streamline sports training having various means at their disposal to help the swimmers to access higher levels of adaptation in order to facilitate the acquisition of a complete and complex motor behavior.

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Muscle strength is one of the most important motorqualities, which largely influences both the speed ofexecution of movements and the activities that requirestrength and skill (Popovici, Suciu, 2013).Various studies have shown that lower body strength is a key determinant of starting performance in sprinting (Cronin, Hansen, 2005 cited by West et.al., 2011) and that increasing lower body strength can lead to improvements in sprinting ability (Coutts et.al, 2004, Hoffman et.al.2004, Kraemer et.al. 2000, cited by West et.al., 2011).The basis of dry-land training should be centered around symmetry and aiming to enhance strength and power to improve performance for the dive and turn, too.

The aim of this research was to identify the evolution of the strength parameters at the lower , in dry land training , parameters that are specific to the swimmers aged between 10 – 14 years.

The objectives of this research were focused on the next issues:

- establishing the monitoring way of the lower limbs strength characteristics evolution, in dry land trainings, for the subjects of the research;
- highlighting the importance of the strength characteristics monitoring in dry land trainings aimed to the swimmers aged between 10 and 14 years;

Methods

Eight swimmers, one female and seven males, aged between 10 to 14 years, members of Elite Swimmers Association took part in this study. They have been monitored for three months (December 2014 - February 2015) while they attended to a training schedule that involved two sessions per week of dry land trainings focused on lower limb strength characteristics improvement. After each month they were tested by using the Kistler Quattro Jump force plate. The research methods that were used in order to accomplish this study were: the case study method, experiment method, testing method, specialty literature study, observation and statistical method.

Results

The results of this study were obtained by using the Kistler Quattro Jump force plate, following it's Bosco protocol, but without the Squat Jump with additional body weight. The data were exported in Excel where they were ordered and tabled for each swimmer as it can be seen in table 1 to 5. The monitoring aimed the emphasizing of the tests' parameters' evolution that are specific to the Bosco protocol, especially for the jump height, instantaneous force and contact time.

From the results that are presented in table 1 we can observe that three of the eight swimmers present an increase of the jump height from a test to another (S1, S2, S7), two of them having a lower value in the third test compared with the first (S3 and S5), and five of them having lower values in the second test then the first (S3, S4, S5, S6).

Table 1. The Squat Jump (SJ) parameters obtained by the swimmers during the monitoring tests

Swimmers	**S1**			**S2**			**S3**			**S4**		
Jump parameters	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg
T1	33.1	-40.7	18.8	48.5	-3.5	13.6	62.5	-1.6	13.4	58.8	-9.5	18.9
T2	55.8	-3.4	14.5	54.2	-4.9	13.3	51.4	-7.7	13.3	58	-18.2	16.1
T3	56.7	-3.6	15.5	56.1	-5.7	13.8	54.3	-6.4	13.1	61.3	-10	18.1
AVG	48.53	-15.90	16.27	52.93	-4.70	13.57	56.07	-5.23	13.27	59.37	-12.57	17.70
SD	13.37	21.48	2.25	3.96	1.11	0.25	5.76	3.21	0.15	1.72	4.89	1.44
	S5			**S6**			**S7**			**S8**		
Jump parameters	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg
T1	61.9	-6.1	15	69.5	-6.6	18.1	52.4	-12.7	11	67.2	-8.56	17.3
T2	54.2	-12	13.7	68.5	-8.6	17.2	53.6	-15.4	11.9	64.7	-12	15.9
T3	57.6	-11.2	14.6	70.5	-4.8	18.6	55.3	-16.5	13.1	68.1	-10.9	18.9
AVG	57.90	-9.77	14.43	69.50	-6.67	17.97	53.77	-14.87	12.00	66.67	-10.49	17.37
SD	3.86	3.20	0.67	1.00	1.90	0.71	1.46	1.96	1.05	1.76	1.76	1.50

∗- Rise of center of gravity, jump height [the maximum displacement of the center of mass of during flight time = jump height curve]
¤ - Squat position (center of mass)
† - Pavg - Average concentric power [(P(t)) from the time when v(t) becomes positive until takeoff]

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By analyzing the values from table 2 we can see that S1 has an ascendant trajectory of these from one testing to another regarding the "hf" parameter (31, 6 cm; 34 cm; respectively 36 cm). Still, he presents a variance of the Fi parameter. The sixth swimmer emphasizes a progressive evolution of the both parameters during the three tests.

The second and the seventh swimmer present successive increases during the testing regarded to the "hf" parameter. In the first case, the Fi parameter records a sinusoidal evolution from the first to the third test. The S7 swimmer is revealing a progressive increasing. In the case of S3 swimmer, the "hf" parameter presents the maximum value in the first test (42,3 cm) while the Fi parameter gets its maximum value in the last test.

Table 2. The Counter Movement Jump (CMJ) parameters obtained by the swimmers during the monitoring tests

Swimmers	S1				S2				S3				S4			
Jump parameters	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]
T1	31.6	-34.5	20.3	1.19	26.9	-37.7	17.3	1.08	42.3	-37.5	17.4	0.78	42.3	-35.4	25.4	1.19
T2	34	-38.1	19.9	1.18	31	-34.8	17.5	1.07	36.3	-33.4	17.2	0.63	45.4	-41.7	23.1	1.25
T3	36	-39.54	22.5	1.23	35	-33.9	18.1	1.11	41.8	-35.2	19.8	0.83	43.7	-37.5	38.4	1.16
AVG	33.87	-37.38	20.90	1.20	30.97	-35.47	17.63	1.09	40.13	-35.37	18.13	0.75	43.80	-38.20	28.97	1.20
SD	2.20	2.60	1.40	0.03	4.05	1.99	0.42	0.02	3.33	2.06	1.45	0.10	1.55	3.21	8.25	0.05

	S5				S6				S7				S8			
Jump parameters	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]
T1	35.3	-47.9	19.8	1.21	40.8	-50.1	21.7	0.94	35.5	-46.6	16.8	0.71	33.2	-45.6	18.2	1.13
T2	34.5	-47.2	19.3	1.18	41.5	-51.3	21.9	0.98	35.9	-47	17.1	0.79	32.4	-43.2	17.9	1.18
T3	36.7	48.2	20.1	1.24	43.8	-51.1	22.6	1.21	38.4	-48.9	19.5	0.90	37.3	-49.1	20.1	1.34
AVG	35.50	-15.63	19.73	1.21	42.03	-50.83	22.07	1.04	36.60	-47.50	17.80	0.75	34.30	-45.97	18.73	1.22
SD	1.11	55.28	0.40	0.03	1.57	0.64	0.47	0.15	1.57	1.23	1.48	0.06	2.63	2.97	1.19	0.11

∗- Rise of center of gravity, jump height [the maximum displacement of the center of mass of during flight time = jump height curve]
¤ - Squat position (center of mass)
†Pavg - Average concentric power [(P(t)) from the time when v(t) becomes positive until takeoff]
∞ - Instantaneous Force [Force at the transition from eccentric to concentric contraction (when the Power first becomes positive)]

From the table 3 data we can observe that only one swimmer (i.e. S8) managed to increase his "hf" values from a test to another (32, 6 cm; 33 cm and 33, 3 cm). At the opposite side, three swimmers decreased their performance from test 1 to test 3 (i.e. S2 [25.2 cm; 25.1 cm; 24.9 cm]; S5 [31 cm; 24.3 cm; 30.5 cm] and S6 [44.9 cm; 38 cm; 44 cm]).

Table 3. The Continuous Jump Bent Leg Reference (CJbref) parameters obtained by the swimmers during the monitoring tests

Swimmers	S1				S2				S3				S4			
Jump parameters	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]
T1	27.4	-38.7	17.6	1.18	25.2	-48.4	15.6	1.71	29.5	-42.7	16.2	0.92	36.8	-31.9	19.8	0.61
T2	28.2	-38.9	17.7	1.18	25.1	-34.3	15.5	0.99	29	-37.9	16.9	0.84	35.7	-35.6	22.5	1.19
T3	27.7	-34.1	18	1.19	24.9	-33.9	15.1	1.01	30.2	-40.9	16.6	0.81	37.9	-31	19.6	0.47
AVG	27.77	-37.23	17.77	1.18	25.07	-38.87	15.40	1.24	29.57	-40.50	16.57	0.86	36.80	-32.83	20.63	0.76
SD	0.40	2.72	0.21	0.01	0.15	8.26	0.26	0.41	0.60	2.42	0.35	0.06	1.10	2.44	1.62	0.38

	S5				S6				S7				S8			
Jump parameters	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]
T1	31	-55.8	18.5	1.23	44.9	-57	22.1	1.19	30.3	-50.3	16.6	1.14	32.6	-41	17.9	1.11
T2	24.3	-43.9	17.5	0.95	38	-45.4	20.2	1.13	30.2	-50.1	16.3	1.23	33	-39.4	18.3	1.14

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T3	30.5	-58.4	18	1.25	44	-54.8	22.3	1.16	32.5	-54.1	17	1.23	33.3	-38.7	18	1.03
AVG	28.60	-52.70	18.00	1.14	42.30	-52.40	21.53	1.16	31.00	-51.50	16.63	1.20	32.97	-39.70	18.07	1.09
SD	3.73	7.73	0.50	0.17	3.75	6.16	1.16	0.03	1.30	2.25	0.35	0.05	0.35	1.18	0.21	0.06

∗- Rise of center of gravity, jump height [the maximum displacement of the center of mass of during flight time = jump height curve]
¤ - Squat position (center of mass)
†Pavg - Average concentric power [(P(t)) from the time when v(t) becomes positive until takeoff]
∞ - Instantaneous Force [Force at the transition from eccentric to concentric contraction (when the Power first becomes positive)]

In table 4 we can observe that three swimmers (i.e. S4: 37.6 cm vs. 242ms; S6: 36.7 cm vs. 276 ms and S8: 34 cm vs. 204ms) performed the jumps having the lowest contact time in the third testing session corresponding to the highest flight jump. As we can see the most efficient jump was performed by S4 in terms of flight jump vs. contact time.

Table 4. The Continuous Jump Straight Legs (CJs) parameters obtained by the swimmers during the monitoring tests

Swimmers	S1				S2				S3				S4			
Jump parameters	hf∗ [cm]	Pavg† [W/Kg]	tcont†† [ms]	k∞ [kN/m]	hf∗ [cm]	Pavg† [W/Kg]	tcont†† [ms]	k∞ [kN/m]	hf∗ [cm]	Pavg† [W/Kg]	tcont†† [ms]	k∞ [kN/m]	hf∗ [cm]	Pavg† [W/Kg]	tcont†† [ms]	k∞ [kN/m]
T1	26.3	27.5	244	14.4	23.4	28.7	195	16.54	30.5	33	250	10.42	36.4	35.6	296	9
T2	28.8	28.5	293	10.78	25.6	31.1	207	15.43	29	30.2	290	10.51	34.7	38.4	229	16.8
T3	33.8	29.6	364	6.24	26.8	31.8	216	14.57	34.1	22	544	2.07	37.6	39.6	242	13.92
AVG	29.63	28.53	300.33	10.47	25.27	30.53	206	15.51	31.20	28.40	361.33	7.67	36.23	37.87	255.67	13.24
SD	3.82	1.05	60.34	4.09	1.72	1.63	10.54	0.99	2.62	5.72	159.45	4.85	1.46	2.05	35.53	3.94
	S5				S6				S7				S8			
Jump parameters	hf∗ [cm]	Pavg† [W/Kg]	tcont†† [ms]	k∞ [kN/m]	hf∗ [cm]	Pavg† [W/Kg]	tcont†† [ms]	k∞ [kN/m]	hf∗ [cm]	Pavg† [W/Kg]	tcont†† [ms]	k∞ [kN/m]	hf∗ [cm]	Pavg† [W/Kg]	tcont†† [ms]	k∞ [kN/m]
T1	25.5	27	242	10.32	32.6	30	293	13.18	26.9	25.6	240	15.85	31.7	30.3	276	14.95
T2	27.7	29.2	282	7	28.7	28.9	233	20.58	25.1	24.2	240	16.04	32	34.5	212	24.27
T3	27.2	28.8	290	7.1	36.7	35.4	276	13.66	25.9	24.3	246	15.87	34	38	204	26.7
AVG	26.8	28.33	271.33	8.14	32.67	31.43	267.33	15.81	25.97	24.7	242	15.92	32.57	34.27	230.67	21.97
SD	1.15	1.17	25.72	1.89	4.00	3.48	30.92	4.14	0.90	0.78	3.46	0.10	1.25	3.86	39.46	6.20

∗- Rise of center of gravity, jump height [the maximum displacement of the center of mass of during flight time = jump height curve]
† - Pavg - Average concentric power [(P(t)) from the time when v(t) becomes positive until takeoff]
†† - Contact time
∞ - Leg Pseudo Stiffness

Analyzing the data from table 5 we can see that the height of the jump and the contact time present an efficient path for S2, S3, S4 and S7. The efficiency of the jump is reflected from the ratio of the height of the jump and the contact time. The other swimmers performed values with low indices of correlation between the two parameters.

Table 5. The Continuous Jump Bent Legs (CJb) parameters obtained by the swimmers during the monitoring tests

Swimmers	S1					S2					S3				
Jump parameters	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	tcont†† [ms]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	tcont†† [ms]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	tcont†† [ms]
T1	23.2	-27.7	16.7	1.12	570	23.3	-29.5	13.5	0.83	748	27.6	-33.3	15.1	0.67	756
T2	25.5	-35	16.5	1.06	714	23.5	-34.6	14.4	0.95	687	27.4	-35.1	14.9	0.72	793
T3	24.3	-35.1	15.8	1.1	666	25.8	-32.4	15.6	0.82	646	28.1	-27.5	18	0.67	598
AVG	24.33	-32.60	16.33	1.09	650	24.20	-32.17	14.50	0.87	693.67	27.70	-31.97	16	0.69	715.67
SD	1.15	4.24	0.47	0.03	73.32	1.39	2.56	1.05	0.07	51.33	0.36	3.97	1.73	0.03	103.57
Swimmers	S4					S5					S6				
Jump parameters	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	tcont†† [ms]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	tcont†† [ms]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	tcont†† [ms]

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T1	27.6	-33.3	15.1	0.67	756	25	-44.4	15.5	0.97	849	40.5	-58.2	20.8	1.44	1018
T2	27.4	-35.1	14.9	0.72	793	26.8	-38.4	16.8	0.83	753	31.9	-38.4	19.7	1.24	713
T3	29.1	-32.1	17.5	0.86	628	28.6	-43.5	17.4	0.86	792	39.4	-40.9	22.8	1.31	674
AVG	28.03	-33.50	15.83	0.75	725.67	26.80	-42.10	16.57	0.89	798	37.27	-45.83	21.10	1.33	801.67
SD	0.93	1.51	1.45	0.10	86.58	1.80	3.24	0.97	0.07	48.28	4.68	10.78	1.57	0.10	188.36

Swimmers	S7					S8				
Jump parameters	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	tcont†† [ms]	hf∗ [cm]	hc¤ [cm]	Pavg† [W/Kg]	Fi∞ [BW]	tcont†† [ms]
T1	29.3	-52.5	16.4	1.23	832	26.8	-38.4	16.8	0.83	753
T2	28.7	-50.4	16	1.16	838	27.4	-37.1	17.7	1.2	712
T3	30.7	-49.7	17.1	1.23	796	28.6	-43.5	17.4	0.86	792
AVG	29.57	-50.87	16.50	1.21	822	27.60	-39.67	17.30	0.96	752.33
SD	1.03	1.46	0.56	0.04	22.72	0.92	3.38	0.46	0.21	40

∗- Rise of center of gravity, jump height [the maximum displacement of the center of mass of during flight time = jump height curve]
¤- Squat position (center of mass)
† - Pavg - Average concentric power [(P(t)) from the time when v(t) becomes positive until takeoff]
∞ - Instantaneous Force [Force at the transition from eccentric to concentric contraction (when the Power first becomes positive)]
†† - Contact time

Discussions

The data that are presented in tables 1-5 are emphasizing a series of aspects that constitute an objective indicator of dry land training guiding for the swimmers that took part in this study. These aspects are reflected from the understanding of the parameters specific to each type of jump that represent part of the Bosco protocol. So, as it concerns the Squat Jump (SJ) test (table 1), the values show an increase of the jump height to almost all of the swimmers which means an increase of the capacity to accomplish the concentric muscular contractions.

Regarding to the Counter Movement Jump test (CMJ) (table 2), the results give the possibility to correlate the jump height with the ability to exert an instantaneous force. In the case of the "hf" the specialists (Garrido et. al., 2010) presents data that are framed between 25 cm and 28 cm while the values of our study subjects are framed between 26,9 cm – 45,8 cm, respectively 0,63% BW – 1,34 %BW for "IF" parameter.

The Continuous Jump with Bent Leg Reference (CJbref) parameters (table 3) obtained by the swimmers during the monitoring tests present values of the "hf" indicator framed between 24,3 cm – 44,9 cm. On the other hand, the Instantaneous Force emphasizes values between 0,47 %BW and1,25 %BW.

Concerning the Continuous Jump Straight Legs (CJs) parameters (table 4), the results offer important data that give to the monitoring activity a superior level of objectivity that concerns the appreciation of the improvement level of the strength features. Among the parameters of this jump, beside the jump height, we have the contact time. The correlation of these two parameters have a major significance in guiding the strength training, especially in what concerns the strength-velocity relation (power). So, the averages of the two parameters varies between 25,27 cm and 36,23 cm for the jump height , respectively 206 ms and 361,33 ms.

The values of the parameters obtained during the Continuous Jump Bent Legs (CJb) (table 5) offer information about the effort capacity specific to the strength indicators. Among the parameters specific to this type of jump, a defining role in the appreciation of the strength capacity comes to the jump height, instantaneous force and contact time. The specific data of these parameters present averages between 24,20 cm and 37,27 cm concerning the "hf"; 0,69 % BW and 1,33 % BW concerning the instantaneous force, respectively 650 ms and 822 ms in the case of contact time.

Conclusions

The identification of the strength indicators evolution for the lower limbs level was reflected in the dynamics of the parameters' values of each type of jump from the Bosco protocol that comes with the Kistler Quattro Jump force plate utilization.

Monitoring the evolution of the lower limbs strength regarded to dry land trainings represents an objective and useful mean for coaches in order to correlate the effects of dry land with the specific (water) training. In the same time, this kind of training approach guides them toward their mission which is to help the swimmers to achieve effective adaptation to the specific effort that can be transformed in the ability to express a better motor behavior.

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