MORPHOLOGICAL CHARACTERISTICS OF ATOP-LEVEL BODYBUILDER DURING PREPARATION FOR COMPETITION: A CASE STUDY

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Abstract
Trend Analysis is a statistical method often used in Kinesiology for tracking progress and predicting sport results. Tracking dynamics of present sport results and records provides information that can be used for predicting sport results in the future. Competitive bodybuilding has two main conditioning goals; the first is to develop new, additional muscle mass during the off season period called "mass".The second goal isto achieve "definition". During this period the effort is to maintain the maximum amount of muscle mass while body fat is reduced to a minimum level.In the current literature there is insufficient information showing the trend of morphological characteristics of elite athletes in general, especially in bodybuilding. Therefore the main objective of this study is to show such changes during conditioning cycles of mass and definition, and to determine their trend during one-year conditioning process of a top-level body builder. A series of regression analyses were performed to attain the relation between training program and certain morphological characteristics. Correlation coefficients showed that the training process had a great influence on the morphological characteristics of the subject. Regression analysis also provided the regression coefficients and time function of trends of morphological characteristics during mass and definition periods. During the mass period all morphological characteristic demonstrated a steep trend of growth in the first 10 weeks (best approximated as polynomial functions of a third degree). The remaining period of time shows a stagnation of morphological values. The definition period has a linear trend (linear functions) and affects the body equally during the whole period. Functions and trends of morphological characteristics of a top-level bodybuilder can be used as a model in future preparations for competitions of this athlete, and also for other competitors with the same or similar morphological characteristics.

Key words: *programmed training process, trend analysis, case study.*

Introduction

Kinesiology as a science has particular interest in studying the influence of the physical exercise on the human body. For studying such influence, very particular forms of exercise has to be applied. Quantitative changes that describe the status of the studied subject, that can be tracked periodically and are analyzed later, are of the utmost importance. The starting point for tracking changes over time is displayed as "Time Sequence", basically a set of chronologically arranged variables. The Time Sequences are usually composed of frequencies related to the same time intervals. By the analysis of Time Sequences it is possible to describe trend of results and their changes over time.

It is then possible to describe variations of the results under the influence of different circumstances; and it is also possible to predict the trend of results in order to control the conditioning process. Time series analysis is most commonly presented by trend and random variations (Šošić & Serdar, 1992).

The Trend Analysis in Kinesiology is most commonly used for analysis of progress and for prediction of sport results. The predominant research is directed towards analysis of sport records in sports such as track and field, swimming or weight lifting (Zaciorski, 1973; Wazny, 1978; Pavičić, 1987; Lukenda, 1988; Bogunović, 1990).

However, there are an insufficient number of published research studies covering single case studies in any sport. Testing and research results conducted on top-level athletes are usually well kept secrets and they are greatly inaccessible; or they are mostly related to clinical or rehabilitation treatments. For bodybuilding as competitive sport, there is not sufficient information regarding specifics of training and conditioning processes, such as contents of trainings or intensity and volume of exercising, especially in the relationship to their influence on morphological changes on the athlete's body. Development of symmetrical, overall muscle mass of the body is a primary goal of bodybuilding. Additionally, targeted development of muscle mass on less developed areas of the body is specifically designed to improve body symmetry. As a side product of this bodybuilding training it is reasonable to expect increase in muscle strength and endurance[8]. As stated previously, it is commonly accepted that conditioning of competitive bodybuilders is divided into two main cycles, namely *mass* (as off season conditioning), and *definition* (as direct conditioning for competition) (Čorak, 2001). During off season conditioning, all efforts are directed towards development of new additional muscle mass (Čorak, 2001; Meletis & Zabriskie, 2005). The competitor will likely increase food intake and his foundational training routine will consist of high intensity resistance training.

Aerobic activity (also known as cardio training) will be reduced to a minimal level, or it will be completely eliminated from the regular training routine. During mass, it is reasonable to expect accumulation of additional amount of storage fat (around 15-17%) (Too, Wakayama, Locati & Landwer, 1998). During conditioning for competition, the definition phase, the main objective of competitive bodybuilder is to reduce excess of fat deposits accumulated during the off season conditioning (Čorak, 2001). Also, during definition it is of utmost importance to protect muscle mass loss while fat deposits are being reduced to a minimum level (Van Der Ploeg, Brooks, Withers, Dollman, Leaney& Chatterton, 2001). Even though personal conditioning styles vary greatly from one individual to another, it is commonly expected that, during definition competitors will reduce food intake (Rankin, 2002), and increase volume but reduce intensity of applied resistance training (namely, the number of sets and repetitions will increase, but resistance used in each exercise will be reduced). Usage of aerobic activities during definition will significantly increase compared to mass period (Kelley & Kelley, 2006; Okura, Nakata, Lee, Ohkawara & Tanaka, 2005, Volek & Vanheest, 2005; Pollock & Jackson, 1984). There is no published information known to authors regarding the morphological characteristics of top-level competitive bodybuilder during one year conditioning process. Therefore, the main objective of this paper is to determine trend of morphological characteristics and their changes over the year-long programmed training process of mass and definition on the single subject for the competitive season 2005/06.

Methods

*Subject**s***

The data was acquired by conducting measurements on single-subject, 38 year old male bodybuilder, during his conditioning for the Mr. Universe 2006 competition. The data collection covered the time period from October 15th 2005,to October 7th2006, and it was conducted in Denver, Colorado, USA. The subject was involved in competitive bodybuilding for approximately 15 years. Prior to, and during the time period analyzed for this research, the subject did not have any injuries and/or illnesses that could compromise validity and reliability of acquired, and presented data.

PrograMmed training process

During the one-year conditioning process, the subject utilized resistance training exercises designed to train all major muscle groups of the body. During both main conditioning cycles (macro-cycles of mass and definition) the subject utilized micro-cycles known as ABCD. Comprised of four trainings in which all major muscle groups of the body are covered usually once (sometimes more) by the resistance training stimulus. Each micro-cycle of training lasted between 4 and 7 days (Čorak, 2001).

Generally, contents of each micro-cycle were identical during the macro-cycle of mass and definition (Tables 1 and 2). Possible differences between certain micro-cycles were caused by minor injuries or illnesses, training exhaustion, orsaturation by certain training principle and structure. In such cases micro-cycles were slightly adjusted to optimally fit demands of particular circumstances. Specifics of training for macro-cycles of mass and definition are specified in Table3.

Table 1: Exercises utilized for each major muscle group of the body

	Muscle group	Exercise
1	Abdominals	1. Sit ups on decline bench 2. Crunches with emphasized stretching
2	Shoulders	Front portion 1. Front shoulder press, seated 2. Dumbbell shoulder press, seated Middle portion 1. Side dumbbell raises Rear portion 1. Rear dumbbell raises
3	Chest	Upper portion 1. Incline bench press on smith machine Middle and lower portion 2. Flat bench press 3. Peck-deck ply - butterfly 4. Push-ups on parallel bars
4	Arms	Biceps 1. Biceps curls - Scott's bench 2. Free bar biceps curls 3. Concentration biceps dumbbell curls Triceps 1. Narrow grip bench press 2. Dips on parallel bars 3. Cable triceps extensions
5	Back	Upper portion 1. Shoulder shrugs on smith machine 2. T-bar rowing Middle portion 1. Front lat pull down, wide grip 2. Lat pull down, narrow grip 3. Low pulley rowing
6	Legs	Calves 1. Calf raises, both legs 2. Calf raises, single leg on leg pressHamstrings 1. Laying leg curl 2. Seated leg curl Quadriceps 1. Squats 2. Smith machine squat 3. Hack squat 4. Lunges with dumbbells 5. Leg extension

Table 2: Structure of training resistance

	Sets	Repetitions	Rest (sec)
Mass	3-5	6-10	90-120
Definition	4-6	6-12	60-90

Table 3: Typical micro-cycle of training

Day of training/rest	Muscle group
Day 1	Abdominals, chest, triceps
Day 2	Back, biceps
Day 3	Abdominals, shoulders, arms
Day 4	Legs
Day 5	Rest

Variables

Measurements were obtained every fifteen days which created series of morphological characteristics. Morphological characteristics that were measured are as follow: body mass (kg), body fat (%), volume of chest, under arms, inhaled (cm), volume of waist (cm), volume of upper arm in flexed position (cm), volume of thigh in extended position (cm), and volume of calf (cm). Protocol of obtaining measurements:

1) Body weight (kg): always measured before workout, in the same clothing, at the same time and on the same scale;

2) Body fat (%): data was calculated by obtaining skinfold measurements (Pollock & Jackson, 1984) from three locations; upper arm, chest and back (Mišigoj-Duraković, 2008);always before workout, with the same measuring person and with the same caliper. Measuring process was conducted three times for accuracy;

3-7). Volume of chest, under arms, inhaled (cm), volume of waist (cm), volume of upper arm in flexed position (cm), volume of thigh in extended position (cm) and volume of calf (cm): measurements were obtained by the same person, using the same tape measure and always before the workout. Measuring process was conducted three times for accuracy.

Statistics

After the data was collected by the repeated measuring, data entry and processing was conducted by a statistical program *Statistica for Windows Ver. 7.1.* (StatSoft, Inc., Tulsa, OK)for personal computers. Increments and decrements of values for morphological characteristics of the body were calculated and expressed in absolute and relative values for periods of mass and definition. Series of Simple Regression analysis were conducted with the goal of finding functional connections between the programmed training process and achieved morphological changes. The goal was to determine a trend of changes for body mass, body fat and volumes for chest, waist, upper arm, thigh and calf.

Results

The range of morphological changes recorded from the initial to the final measuring for the subject's training are presented in the Table 4. Explicitly, the table shows increments in body mass, body fat and volume measurements during mass period. During the definition period, the table shows decrements of named morphological characteristics. All values are presented in the absolute and relative values.

Table 4: The range of recorded morphological characteristics (absolute and relative values)

		Body weight (kg)	Body fat (%)	Volume Chest (cm)	Volume waist (cm)	Volume pper arm (cm)	Volume thigh (cm)	Volume calf (cm)
mass	Kg cm	17.75	6.5	5.75	13.25	2.25	3	1.25
	%	14.92	72.22	4.07	14.64	4.37	3.84	2.49
definition	Kg cm	-31	-11.7	-10	-24.75	-4	-4.25	-2.5
	%	-22.67	-75.49	-6.80	-23.86	-7.44	-5.23	-4.85

With the series of Simple Regression analysis, statistically significant correlations have been determined between programmed training process and noted morphologicalcharacteristics(Table5).

Table 5: Multiple regression coefficients (r), coefficients of determination (r^2) and p-levels

		Body weight (kg)	Body fat (%)	Volume Chest (cm)	Volume waist (cm)	Vol. upper arm (cm)	Volume thigh (cm)	Volume calf (cm)
Mass	R	0.95	0.98	0.97	0.98	0.89	0.95	0.96
	R^2	0.90	0.96	0.95	0.96	0.79	0.90	0.93
	p	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Definition	R	0.99	0.99	0.96	0.98	0.95	0.97	0.96
	R^2	0.98	0.98	0.92	0.96	0.90	0.95	0.93
	p	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Regression Analysis provided regression coefficients from which the time functions of the trendsof morphological characteristics were extracted (Table6). Such regression coefficients represent the average value of the dynamic, and they are obtained by the least square method.

Table 6: Functions of the trends of morphological characteristics in mass and definition periods

	Mass	Definition
Body weight	$y=117.5+4.3x-0.3x^2+0.01x^3$	y=141.4-4.4x
Body fat	$y=7.9+2.2x-0.2x^2+0.01x^3$	y=17.3-1.8x
Volume of the chest	$y=140.4+1.6x-0.1x^2+0.03x^3$	y=149.0-1.5x
Volume of the waist	$y=90.6+2.1x-0.1x^2+0.001x^3$	y=103.1-3.5x
Volume of the upper-arm	$y=51.6+0.4x-0.02x^2+0.001x^3$	y=54.4-0.6x
Volume of the thigh	$y=77.8+0.6x-0.02x^2+0.003x^3$	y=82.1-0.6x
Volume of the shin	$y=50.5+0.1x+0.01x^2+0.001x^3$	y=51.6-0.3x

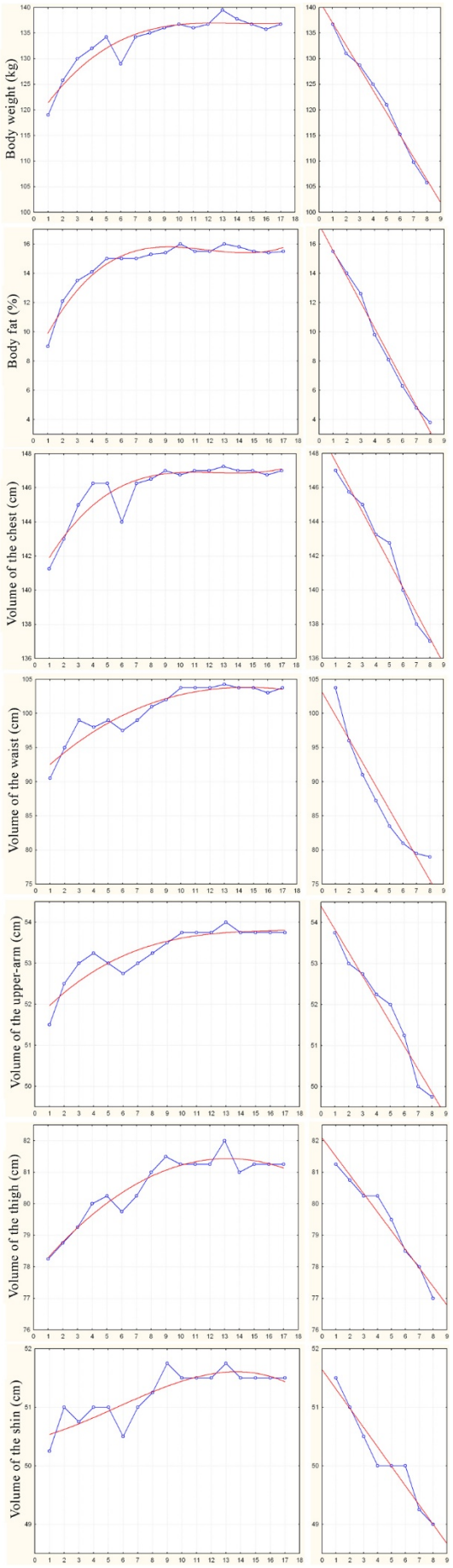

Figure 1. Trends of changes of morphological characteristics during mass (left graphs) and definition periods (right graphs)

The recorded results are also presented by graphs, which include level of development of morphological characteristics in time (Figure1). The graphs clearly show dynamics and trend of increment and/or decrement of values.

Discussion

By evaluating the range of results it is obvious how much values have increased or decreased for each variable in absolute and relative terms(Table4). The goal of mass period is to develop muscle mass; during that conditioning stage it is reasonable to expect accumulation of additional body fat as shown in the graphs. Too et. al. determined that body fat at the end of mass period is expected to be in the range of 15-17%; which was the case with our subject whose body fat percentage was 15.5%. The subject increased his body fat percentage by 72.22% from the initial measurement obtained at the beginning of mass period. Total mass was increased by 17.75 kg, which is 14.92%.Predominant accumulation of fat deposits was noted in the middle portion of the body (waist) which has resulted in increased volume measurement of waist by 14.64%, explicitly from 90.5 cm to 103 cm. Volume measurements of extremities showed smaller increase in values of 2.49-4.37%. Based on such results, our subject could be categorized into android or "apple-like" type of adiposity, which has 102cm as the lover value for the volume of the waist (Mišigoj-Duraković, 2008). However, this indicator of risky amount of abdominal fat accumulation is designed for non-selected population and has to be taken with reservation.

Increase in the cross section of abdominal and back muscles also has influence on larger volume of the waist; not only the accumulation of fat tissue. Volumes of extremities were increased predominantly due to the muscle hypertrophy, rather than fat accumulation. During the definition conditioning stage, linear trend of reduction for all morphological values is obvious. The scope of changes in values is even more obvious than during the mass period (basically double). The final results reach levels even smaller than those recorded during the initial measuring. The greatest change of 75.49% is recorded for fat reduction, followed by 23.86% of reduction in volume of the waistand22.67% of body weight reduction.

The range of changes in volume measurements for extremities is related to the desired appearance by the athlete, and cannot be quantified. The changes range from 4.85% to 7.44%. Furthermore, Pearson correlation coefficients, which are statistically significant at the level of $p<0.01$, show that independent variable, i.e. training process, has a great influence on dependent variables, i.e. morphological characteristics of the subject. High coefficients of determination mean significant concerted variance, which represents high predictability of morphological changes based on applied conditioning program.

For the mass period, functions were presented as third-degree polynomial functions; they present the best way to approximate functional dependency for each morphological characteristic in time. For the definition period functions were presented as linear. Figure 1 shows rapid increase of all morphological characteristics during the first 10 weeks of mass period. Total body weight was increased by almost 18 kg, due to increase of body fat (approximately 58% of total weight gain) and increase in muscle mass (approximately 42% of total weight gain). During the remaining time of mass, stagnation of numeric increase for morphological characteristics is noted; increase in the quality of muscle mass is difficult to be explicitly measured and expressed. An identical trend of increased values was recorded for volume measurements. Definition period has a linear trend of influencing measured characteristics during the time. Body mass drops 2.19 kg per week, of which 1.28 kg belongs to body fat. Findings clearly show that conditioning process of definition period significantly influences reduction of body mass and especially reduction of fat deposits on the body. According to the negative prefixes of non-standardized regression coefficients (B1) in Table 6during definition period, it is obvious that such conditioning reduces the volume measurements of chest, waist, upper arm, thigh and calf. More significant reduction of volume measurements is noted for the waist area, which was reduced by 1.72 cm per week. Results show that the conditioning process of definition did not only reduce body fat (especially in the waist area), but also reduced lean body mass. However, as the goal of definition is not muscle gain, but protection of muscle mass during the process of fat reduction, obtained results are consistent with such goals.

Conclusion

The research was conducted during the competition season 2005/06 and included programmed training process consisted of mass and definition periods. This was a single case study; the subject was preparing for the bodybuilding competition Mr. Universe.

The goal of this research was to determine quantitative changes of some morphological characteristics and their trend under the influence of specific training process. During the mass period subject wanted to increase his body weight, mostly due to increase in muscle mass and with minimal accumulation of body fat. During the definition period, the goal was to eliminate as much as possible storage fat on the body, and maintain muscle mass.

This research has determined the influence of programmed training process on certain morphological characteristics. The series of simple regressions provided functional connections between conditioning processes of mass and definition and morphological characteristics of body weight, body fat, and volumes of chest, waist, upper arm, thigh and calf.

Created functions and trend of morphological changes can be used by the subject as model values for future Mr. Universe or other competitions. In addition to our subject these functions will come handy to other entities with identical or similar morphological characteristics. Tracking of results provides answers about structure and quality of applied conditioning programs. It also gives modal values to be achieved for upcoming competitions.

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MORFOLOŠKE KARAKTERISTIKE VRHUNSKOG BODYBUILDERA TIJEKOM PRIPREMA ZA NATJECANJE: PRIKAZ SLUČAJA

Sažetak

Za praćenje razvoja i prognoze sportskih rezultata u Kineziologiji često se koristi analiza trenda. Praćenje dinamike sportskih rekorda daje uvide o pravilnosti koja omogućuje racionalan razvoj predviđanja sportskih rezultata u budućnosti. U profesionalnom *bodybuildingu* jedan od glavnih ciljeva je izgradnja dodatne mišićne mase i gubitak što je moguće više masnog tkiva tijekom dva osnovna razdoblja: mase i definicije. Kako do sada u literaturi nije prikazan trend morfoloških karakteristika vrhunskih sportaša, osobito u *bodybuildingu*, upravo je glavni cilj ovog istraživanja prikazati kako se određene morfološke karakteristike mijenjaju tijekom perioda mase i definicije te utvrditi njihov trend promjena pod utjecajem jednogodišnjeg programiranog trenažnog procesa vrhunskog *bodybuildera*. Serijom regresijskih analiza dobiveni koeficijenti korelacije pokazuju kako je trenažni proces imao značajan utjecaj na sve morfološke karakteristike. Također, dobiveni su regresijski koeficijenti i vremenske funkcije trendova morfoloških karakteristika tijekom mase i definicije. Sve morfološke karakteristike tijekom perioda mase pokazale su strm trend rasta u prvih 10 tjedana (najbolje aproksimirane kao polinomi trećeg stupnja). Preostali period je stagnacija morfoloških vrijednosti. Period definicija ima linearni trend (linearne funkcije) i pogađa podjednako sve morfološke karakteristike tijekom cijelog razdoblja. Dobivene funkcije i trendovi morfoloških karakteristika vrhunskog *bodybuildera* mogu se koristiti kao modalne vrijednosti u budućim pripremama za natjecanja ovog, kao i drugih sportaša istih ili sličnih morfoloških karakteristika.

Ključne riječi: *programiranitrenažni process, analizatrenda, pojedinačnislučaj*

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