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Original Article (short paper)

Individual study of anthropometric variation, energy and macronutrients intakes in Paralympic Track and Field athletes in different phases of the season

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Abstract — Aims: a) to measure individual variations in body mass (BM), sum of skinfolds (SSF) and energy intake of Paralympic track and field athletes b) to evaluate whether individual consumption of macronutrients meets recommended levels in three distinct periods of training. **Methods:** Ten Paralympic track and field athletes were evaluated during three periods: 1) end of season, 2) after vacation, and 3) preparation for the Paralympic Games London 2012. Food history and the 24-hour Dietary Recall methods provided information on daily food intake. To assess changes in body composition, we measured skinfolds and BM. Descriptive statistics were utilized to describe individual results. **Results:** BM varied among athletes and phases, but most (n=8) had higher SSF after vacation. Four athletes reported an increase in energy intake of more than 500 kcal during their vacation period, while eight athletes reported maintaining their intake in the preparatory phase for the competition. Carbohydrate intake was adequate for most athletes in the end of season period and in the preparatory phase for competition, and most athletes had reduced lipid intake after vacation and in the preparatory phase. **Conclusion:** We observed important variations in BM and SSF, in food intake and macronutrients between the three evaluated periods. The nutritional status of the athletes suggests that inadequacies that might affect the performance of sprinters and middle-distance runners are more likely to occur during the preparatory period before competitions.

Keywords: energy consumption, macronutrients, body composition, track and field, para-athletes.

Introduction

Paralympic track and field events are multi-disability sports[1], with different types of disciplines and different demands on the body. Good quality individualized nutritiona[1] counseling can help athletes to maximize their performance. However, there is no single diet that can meet all athletes' needs at all times[2].

A good diet supports physical training, reduces the occurrence of disease and injuries and supports physical training[2].Athletes require a diet that can provide enough energy to meet the demands of their training, and avoid any reduction in their performance[3].

In addition, the distribution of macronutrients has to be planned to guarantee the availability of substrates to regulate metabolic pathways, and modulate the muscle-skeleton adaptations induced by physical training[4], with athletes continuously monitoring and adjusting their macronutrient consumption in order to optimize their athletic performance[5, 6].

Although the latest scientific knowledge on nutrition allows diets to be customized and adapted to the peculiarities of each sport/discipline and period of training, athletes frequently do not consume diets that are in accordance with these nutritional recommendations[7, 8].

In Paralympic sports, there is a lack of knowledge about the athletes´ nutritional needs due to the heterogeneity of their disabilities, and also about this population´s food intake[9]. Therefore, it is important to conduct new studies that identify the nutritional and anthropometric profile of this population in different periods of a competitive season.

The objectives of this study were: a) to present individual variations between the evaluated periods of the sum of skinfolds (SSF), of body mass (BM) and energy intake of Paralympic track and field athletes; b) to evaluate actual macronutrient intakes and compare these with the recommended levels for athletes in each analyzed period.

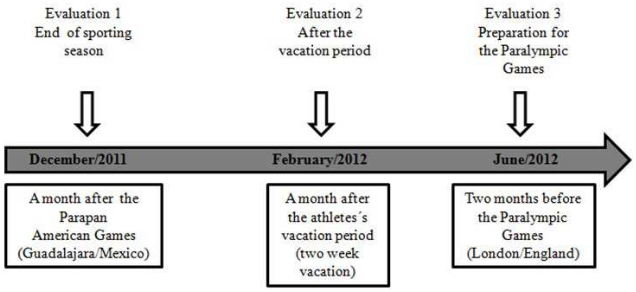
Methods

Experimental design and ethical aspects

The study was approved by the Committee of Ethics in Research of the Federal University of Sao Paulo (#0294/11). All athletes were informed about the objectives of the research and all signed the free and informed consent form.

Data were collected during three consecutive "weeks of evaluation and training" (Figure 1) organized by the Brazilian Paralympic Committee, quarterly, throughout the annual cycle of training. The track and field Paralympic team was evaluated by an interdisciplinary group of professionals.

Figure 1. Experimental Design of the Study



Participants

Ten paralympic athletes (six men and four women), of the Brazilian track and field team, all with experience in international competitions participated in this study. The characteristics of each participant are described in Table 1.

Among the three athletes with cerebral palsy, two had spasticity (participants 1 and 2), and one atony (participant 3). One of the three amputee athletes had an amputation representing less than 2% of BM (participant 6) and two had amputations representing more than 10% of total BM (participants 4 and 5) according to Osterkamp[10], while the four visually impaired athletes were totally blind (participants 7, 8, 9 and 10).

Table 1. Distribution of the athletes by gender, height, disabilities, specialty and sporting classification.

Participants	Height (cm)	Gender	Disabilities	Type of Event	FC*
1	174	Male	CP	100m, 200m, 400m	T38
2	164	Female	CP	100m, 200m	T38
3	172	Female	CP	Javelin/discus throwing/shot put throwing	F37
4	148	Male	MD/amputation	100m, 200m, 400m e 4x100m	T43
5	168	Male	MD/amputation	100m, 200m, 400m e 4x100m	T45
6	174	Male	MD/amputation	100m, 200m, 4x100m	T46
7	176	Male	Visual	100m, 200m, 400m e 4x100m	T11
8	162	Female	Visual	100m, 200m, 400m	T11
9	164	Female	Visual	100m, 200m, 400m	T11
10	181	Male	Visual	1.500m e 5000m	T11

CP = Cerebral palsy; MD = Motor disability; FC= Functional classification; T= *track*; F=*field*; m=meters.

Procedures

Evaluation of Food Intake

Food intake information was obtained using the food history and the 24-hour dietary recall methods. Athletes described in detail all food, beverages and supplements consumed[11].

Athletes reported the size of the consumed portions with the help of a photograph food register[12] with the exception of the visually impaired athletes, who were helped by their guides whenever necessary. Portions recorded were later compared with standard portions as proposed by Medeiros, Pfrimer, Tremeschin, Molina, and Chiarello[13], and converted to grams[14]. The software Avanutri Revolution 4.0® was used to calculate energy intake (kcal/day), and macronutrient intake: carbohydrates (g/kg/day), proteins (g/kg/day) and lipids (% total energy per day). Carbohydrate intakes were compared to the proposed recommendations by Slater and Phillips[15] for thrower and sprinters and those by Thomas, Erdman and Burke[16] for 1500/5000m runners. Protein and lipid intake were compared to the proposed recommendations by Thomas, Erdman and Burke[16] for all athletes.

A cutoff point of 500kcal/day was used to characterize variation in energy intake(kcal/day)[17].

Anthropometry and body composition

The BM(kg) was measured using an electronic scale with a precision of 0.01 kg and height (cm) was measured using a stadiometer with an accuracy of 1 cm. Athletes were evaluated standing up, with their feet together and head placed in the Frankfort plane. For the amputatee athlete (participant 4) this measurement was done without the use of prosthetics.

Body composition was estimated using a Lange® adipometer (with a precision of 1 mm and constant pressure of $10g/mm^2$). Skinfolds were measured on the right side of the body. Athletes with cerebral palsy and motor disability/amputation were measured on the dominant side. Skinfolds (triceps, subscapular, biceps, iliac crest, front thigh and medial calf) were measured with the procedures proposed by the International Society for the Advancement of Kinanthropometry[18], while mid-axillary and chest skinfolds were measured in accordance to Heyward and Stolarczyk[19] and the results are shown in SSF (mm). For the bi-amputatee athlete (participant 4) only eight skinfolds were assessed (exclusion of the medial calf skinfold).

The assessment of changes in lean mass and body fat were based on the interpretation proposed by Slater[20] that combines the information about the variation in BM and SSF to suggest a potential gain or loss of lean mass or body fat.

We utilized a cutoff point of 0.5 kg to characterize change in BM[21, 22] and of 5mm to characterize any change in SSF.

Statistical Analysis

The studied sample showed heterogeneity as to the type of disability and sport discipline therefore we analyzed individual data using the SPSS Statistics software, version 20.0 for descriptive statistics. Average ± standard deviation, absolute values, relative values and their differences (delta) were used to describe the results. Due to the small sample size, the nonparametric Friedman test was used to verify differences among the evaluation periods. The results were described in the form of the median, a robust indicator of central tendency and less sensitive to extreme scores (50th percentile), 25th and 75th percentiles. The level of significance was set at 5% ($p \leq 0.05$).

Results

Athletes were 29.1±6.06 years old and reported a habitual daily training load of 4.25±1.18 hours/day.

Table 2 shows BM and SSF, respectively, in each evaluated period, for each athlete, as well as the individual variation of these variables between periods 1 and 2; and 2 and 3, according to the established cutoff points.

Table 2. Individual analysis of BM and SSF in each evaluated period and their variation between these periods

BM (kg)							
Participants	Av1	Av2	Av3	Δ (Av2- Av1)	BM Variation (Cutoff point = 0,5 kg)	Δ (Av3- Av2)	BM Variation (Cutoff point = 0,5 kg)
1	69.35	69.40	68.17	0.05	↔	-1.23	↓
2	58.42	58.59	59.64	0.17	↔	1.05	↑
3	68.40	69.21	68.77	0.81	↑	-0.44	↔
4	62.79	63.63	62.90	0.84	↑	-0.73	↓
5	54.94	53.63	54.59	-1.31	↓	0.96	↑
6	71.26	70.21	70.72	-1.05	↓	0.51	↑
7	76.94	78.29	77.15	1.35	↑	-1.14	↓
8	50.49	52.60	50.40	2.11	↑	-2.2	↓
9	62.44	62.29	62.72	-0.15	↔	0.43	↔
10	67.94	68.68	67.11	0.74	↑	-1.57	↓
SSF (mm)							
Participants	Av1	Av2	Av3	Δ (Av2- Av1)	SSF Variation (Cutoff point = 5mm)	Δ (Av3- Av2)	SSF Variation (Cutoff point = 5mm)
1	85	93	83	8	↑	-10	↓
2	132	150	154	18	↑	4	↔
3	205	225	224	20	↑	-1	↔
4	112	138	127	26	↑	-11	↓
5	50	49	43	-1	↔	-6	↓
6	75	61	62	-14	↓	1	↔
7	75	83	81	8	↑	-2	↔
8	126	166	141	40	↑	-25	↓
9	126	135	144	9	↑	9	↑
10	55	62	56	7	↑	-6	↓

Δ= delta; ↑ BM variation above 0.5 kg and of SSF above 5mm; ↓ BM variation below 0.5 kg and of SSF below 5 mm; ↔ no variation
Av1= end of season; Av2= post-vacation; Av3 = preparation for the Paralympic Games.

Table 3 describes the energy intake in each evaluated period, variation (absolute and relative) between evaluations 1 and 2, and 2 and 3.

Table 3. Individual analysis of energy intake at each evaluated period and their variation between these periods.

Kcal/day (energy intake)							
Participants	Av1	Av2	Av3	Δ Av2- Av1 (%variation)	Variation Kcal/day (Cutoff point = 500kcal/day)	Δ Av3- Av2 (% variation)	Variation Kcal/day (Cutoff point = 500kcal/ day)
1	1829	2426	2904	597 (32.6%)	↑	478 (19.7%)	↔
2	2578	1875	1718	-703 (-27.3%)	↓	-157 (-8.4%)	↔
3	1667	1982	1927	315 (18.9%)	↔	-55 (-2.8%)	↔
4	1945	2661	1957	716 (36.8%)	↑	-704 (-26.5%)	↓
5	1675	2458	2782	783 (46.7%)	↑	324 (13.2%)	↔
6	2402	2980	2957	578 (24.1%)	↑	-23 (-0.8%)	↔
7	1851	2262	2275	411 (22.2%)	↔	13 (0.6%)	↔
8	1771	1224	1090	-547 (-30.9%)	↓	-134 (-10.9%)	↔
9	2369	1725	2129	-644 (-27.2%)	↓	404 (23.4%)	↔
10	2264	1818	2462	-446 (-19.7%)	↔	644 (35.4%)	↑

Δ: delta; ↑ variation of kcal/day above 500 kcal/day; ↓ variation of kcal/day below 500 kcal/day; ↔ no variation; Av1= end of season; Av2= post-vacation; Av3 = preparation for the Paralympic Games.

Table 4 presents the macronutrients (carbohydrates, proteins and lipids), in each evaluated period, and the level of intake (below, adequate or above recommended values).

Table 5 shows the comparison of BM, SSF, kcal, carbohydrate, protein and lipid intake, among the three evaluation periods. The comparisons were not statistically significant for any of the variables.

Table 4. Comparison of the carbohydrate, protein and lipid intakes with the recommended values, for each evaluated period, per athlete.

Carbohydrate (g/kg/day)						
Participants	Av1	Recommendation	Av2	Recommendation	Av3	Recommendation
1	2.5	↓*	4.0	↔*	5.6	↔*
2	6.6	↔*	4.4	↔*	4.0	↔*
3	3.2	↓*	3.7	↓*	4.4	↔*
4	4.4	↔*	5.6	↔*	4.7	↔*
5	4.0	↔*	7.3	↑*	6.5	↔*
6	5.4	↔*	7.2	↑*	6.9	↔*
7	2.7	↓*	3.8	↓*	4.2	↔*
8	5.3	↔*	3.4	↓*	3.0	↓*
9	4.5	↔*	4.2	↔*	5.1	↔*
10	4.7	↓**	4.3	↓**	4.8	↓**
Protein (g/kg/day)						
Participants	Av1	Recommendation‡	Av2	Recommendation‡	Av3	Recommendation‡
1	2.2	↑	2.4	↑	2.5	↑
2	1.4	↔	1.6	↔	1.1	↓
3	1.5	↔	1.6	↔	1.6	↔
4	1.5	↔	1.8	↔	1.4	↔
5	1.6	↔	2.1	↑	3.3	↑
6	1.6	↔	1.5	↔	1.4	↔

7	2.1	↑	2.0	↔	1.8	↔
8	2.0	↔	1.4	↔	1.5	↔
9	2.3	↑	1.8	↔	1.5	↔
10	2.2	↑	1.4	↔	1.7	↔
Lipid (%Total energy day)						
Participants	Av1	Recommendation§	Av2	Recommendation§	Av3	Recommendation§
1	28.7	↔	26.7	↔	23.4	↔
2	27.4	↔	25.5	↔	27.3	↔
3	22.7	↔	25.4	↔	14.6	↓
4	23.0	↔	28.7	↔	21.2	↔
5	25.4	↔	18.3	↓	22.6	↔
6	17.7	↓	18.2	↓	19.9	↓
7	20.5	↔	19.2	↓	18.8	↓
8	16.5	↓	18.3	↓	17.8	↓
9	28.4	↔	14.6	↓	17.20	↓
10	17.2	↓	14.6	↓	29.6	↔

Av1= end of season; Av2= post-vacation; Av3 = preparation for the Paralympic Games ; ↑ above recommended; ↓ below recommended; ↔ within recommendation;* Recommended according to Slater and Phillips[15] for thrower and sprinters: <4 below; 4 a 7 adequate; >7 above ; **Recommendation according to Thomas, Erdman and Burke[16] for 1500/5000m runner: <6 below; 6 a 10 adequate; >10 above; ; ‡Recommendation according to Thomas, Erdman and Burke[16]<1.2 below; 1.2 a 2 adequate; >2 above; §Recommendation according to Thomas, Erdman and Burke [16]<20% below; 20% a 35% adequate; >35% above.

Table 5. BM, SSF, kcal and macronutrients intake among three evaluations.

Body Composition	Av1			Av2			Av3			Friedman (p value)
	25%	median	75%	25%	median	75%	25%	median	75%	
BM (kg)	57.55	65.32	69.82	57.34	66.15	69.60	58.37	65.00	69.25	0.49
SSF (mm)	70	98	127	61	114	154	60	105	146	0.08
Nutritional Variables										
Kcal	1747	1898	2377	1794	2122	2508	1874	2202	2812	0.49
Carbohydrate	3.0	4.4	5.3	3.7	4.2	6.0	4.1	4.7	5.8	0.27
Protein	1.5	1.8	2.2	1.4	1.7	2.0	1.4	1.5	1.9	0.58
Lipid	17.5	22.8	27.6	17.3	18.7	25.8	17.6	20.5	24.3	0.49

BM = Body mass; kg = Kilograms; SSF = Sum of skinfolds; mm = milimeters; kcal= energy intake. Av1= end of season; Av2= post-vacation; Av3 = preparation for the Paralympic Games. Carbohydrate and protein (g/kg/dia); Lipid (% total energy day).

Discussion

This study evaluated individual variations in BM and SSF and the energy intakes of Paralympic track and field athletes; in addition, we assessed the levels of macronutrient intakes, comparing them to the recommended levels for the athletes at each period.

Few studies have evaluated the body composition of athletes with disabilities due to the lack of a standard method for this population[20]. Van de Vliet, Broad and Strupler[23] suggest the use of SSF (mm) in disabled athletes, avoiding the use of nonspecific predictive equations and allowing the follow up during the evaluated periods.

Furthermore, nutritional recommendations for these para-athletes have not yet been well-defined, with the present recommendations being based on able bodied athletes adapted for para-athletes considering specific aspects of the disabilities functionality, the clinical conditions associated to the disability, and the particular sporting discipline[17, 24,25]. In this study, we point out the importance of joint evaluation of BM and SSF to understand and follow changes in the body mass and body composition of the athletes.

Energy intake varied greatly between evaluation periods. In evaluation 2, the higher energy intake reported by some athletes in relation to evaluation 1 might reflect consumption during the post-vacation period. However, the reported energy intake did not explain all the BM and SSF variations, which perhaps reflects the limitations of the methods of food intake assessment used in the study. Although five athletes (participants 3, 4, 7, 8 and 10) increased their BM in this second evaluation, eight athletes (participants 1, 2, 3, 4, 7, 8, 9 and 10) increased their SSF. This is a frequently observed situation (increased food intake and decreased energy expenditure) when athletes return from vacation and may explain the observed alterations in BM and SSF.

In period 2 the majority of athletes had increased BM and/or SSF. These changes can affect performance. Increased subcutaneous corporal fat, for example, can work as a barrier to heat loss. O`Connor and colleagues[26] pointed out that in marathon athletes increased body fat might negatively impact their performance, especially as heat exchange becomes more important with the increased distance.

In addition, another study showed that excessive fat mass negatively affects performance in other sports[27], such as exercise with gravitational load (e.g., running), as demonstrated in the case of participant 10 in the present study.

The energy deficit reported by some athletes in evaluation 2 might indicate that they were already making adjustment to try to control their BM and/or body composition (participants 2, 8 and 9) although no results among their anthropometric measurements were observed. Our attention was caught by the magnitude of the deficit reported by some athletes (participants 2 and 9). If this was sustained in the long term it might negatively impact their energy availability. According to Mountjoy, Sundgot-Borgen, Burke, Carter, Constantini, Lebrun et. al3, a negative energy balance in athletes may lead to Syndrome Relative Energy Deficiency in Sport (RED-S). In this syndrome, several systems in the human body such as the endocrine, metabolic, hematological, psychological, cardiovascular, gastrointestinal, immune and skeletal may be affected. This condition leads to changes in glycogen stores, muscle strength, aerobic and anaerobic performance, increasing risk of injuries and reducing response to training. Also, some psychological variables may suffer modification including impairment of judgement, decreased coordination and concentration and increased irritability and propensity to depression[3].

From the second to the third evaluation, all athletes, independently of their energy intake report, maintained or reduced their SSF, the results in relation to BM and energy intake were not so clear, athlete 10, for example, reduced their BM and SSF and demonstrated a potential loss of lean mass, although they increased energy intake. This data suggests an effect of increased exercise energy expenditure on body composition. A decrease in lean mass can have a possible positive impact on middle-distance runner performance, according to Mooses, Jürimäe , Mäestu , Purge , Mooses and Jürimäe[28].

Longitudinal analysis showed that only three athletes (participants 5, 6 and 8), all sprinters, managed to increase their lean mass (or "recover" its decrease) and lose body fat (or "recover" its increase) during the last evaluated period. Two visually impaired sprinters (participants 7 and 9) lost lean body mass and gained body fat in the preparatory period for the Paralympic Games, which could, if maintained, negatively affect performance. Barbieri, Zaccagni, Babić, Rakovac, Mišigoj-Duraković and Gualdi-Russo[29] highlighted that sprinters showed a relationship between better personal times and greater fat-free BM.

Athlete 3 gained lean mass and body fat, with a slight increase in energy intake (315 kcal/day) in relation to the 1st evaluation. In the last evaluation, the athlete maintained lean mass, with no reduction in SSF. However, for track and field throwing events an increase in body fat does not have a negative influence[30]. A study suggested that an increase in fat free mass did not improve shot-put performance in this type of event[31].

In the present study, when the median data of each period was observed, carbohydrate and protein intakes were in accordance with the recommended values. However, there were deficiencies in terms of macronutrient intake for some athletes when individual data was analyzed. Therefore, we emphasize the importance of analyzing each athlete individually, as when all athletes were analyzed in the same group in each period, these problems were not identified, because they do not take into account the specificity of the event nor the type of disability.

The macronutrient composition of meals can affect the BM as well as SSF results. For example, athlete 5, in the second evaluated period, lost lean mass without modification of body fat, concomitantly with an increased energy and carbohydrate intake close to the upper recommended values, with low lipid intake and protein intake above the recommended level. In the last evaluation, the athlete gained lean mass and lost body fat, and reduced carbohydrate intake, maintaining it, however, within the recommended limits. Protein intake was again above the recommended level.

The main objective of sprinter athletes is to gain muscle mass and strength. In many cases, these athletes believe that the consumption of protein should be the main focus of their diet[2]. There is novel evidence that suggests higher protein intakes (>3.0 g/kg/d) may have positive effects on body composition in resistance-trained individuals (i.e., promote loss of fat mass)[32]. Although protein plays an important role in an athlete's diet, guidelines in relation to increasing or preserving skeletal muscle mass through protein consumption are complex and depend on multifactorial interactions including the source of the protein, timing, amount, and macronutrient co-ingestion[33]. Moreover, it seems that protein ingestion above the recommended values does not bring any benefit to a runner's athletic performance[34].

Stellingwerff, Maughan and Burke[5], draw attention to the importance of lipids in helping the absorption of liposoluble vitamins which provide substrates for hormone synthesis, and to the maintenance of cell membrane integrity. According to Thomas, Erdman and Burke[16], an inadequate intake of lipids (<20% total energy day) might compromise athletic performance. However, the lipid intake must be in accordance with the training objectives and body composition. In specific periods of training such as during the preparatory period before competitions, lipid intake may be limited to reduce energy intake and, consequently, to reach the desired body composition[5].

Carbohydrate intake is fundamental to the optimization of athletic performance[35]. Besides consuming an adequate daily amount of carbohydrates according to training demands, its distribution during the day, with emphasis pre, during and post-training and recovery, can optimize performance/recovery[15, 16].

Several factors may explain non-adherence to nutritional recommendations by athletes, including the fact that the results of new studies with up to date recommendations do not always reach them quickly. Furthermore, it is not uncommon for athletes to be influenced by information in social media from colleagues and non-qualified professionals. Moreover, very rigid diets which do not take into consideration cultural aspects can lead athletes to quickly reject them[36].

Nutritional educational strategies to develop the athletes' autonomy in choosing healthy food are important steps to improve athletes' diets and thus optimizing their performance[36-38]. Educational strategies involving an understanding of athletes´ food beliefs and practices which encourage them to focus on their own diets have been suggested as being most effective[38].

Therefore, to optimize athletic performance it is necessary to establish a proper eating plan with short and long term goals, using good nutritional practice to increase muscle mass and/or reduce body fat/weight in a safe and effective manner[16].

The present study provides useful information for dietitians on how to analyze information and perform dietetic adjustments, as well as for coaches and physical trainers to provide the necessary adjustments in the training program, in a customized way. In this way, increased body fat and decreased fat-free mass can be avoided, maintaining or improving the physical performance of para-athletes. Conducting periodical assessments to identify changes in body composition , as well as in the energy and macronutrient intake of athletes during different periods, can help to produce a better nutritional strategy, particularly during preparatory and competition periods.

The study limitations are the lack of monitoring of training loads and energy expenditure, which would allow a more detailed analysis of the anthropometric measurements and food intake. In addition, the authors suggest future research uses more evaluation points during training programs to investigate anthropometric, energy and macronutrient intake variables.

Conclusions

We observed important variations in BM and SSF, and in food and macronutrient intake between the three evaluated periods. The nutritional status identified suggests inadequacies that might affect the athletic performance of sprinters and middle-distance runners, particularly during the preparatory periods before competitions.

These results highlight the importance of anthropometric and dietetic evaluations in the monitoring of athletes. In the case of Paralympic athletes, individual analysis allows for more tailored adjustments to be made to meet specific demands.

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