MICRODOSING—RESISTANCE TRAINING FREQUENCY AND ITS IMPLICATIONS FOR SPORTS PERFORMANCE

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INTRODUCTION

One of the most cited reasons for not implementing physical activity into daily living is a lack of time (16,18). As a result of time and logistical obstacles in scheduling, individual and team sport athletes may experience difficulties in incorporating resistance training into their daily and weekly routines. Numerous team and individual sports have competition calendars, both national and international, that are 3 – 9 months in length or longer (10). Regularly included strength training has been shown to improve performance by increasing muscular endurance and muscle hypertrophy, thus promoting strength and power development (6,9,30). Furthermore, as an added benefit to performing a properly structured, periodized resistance training program on a consistent basis, a reduction in injury occurrence may be experienced (22).

The perceived imposition of a lack of time to train may be a result from the traditional model of training. A traditional model of training typically consists of a warm-up, main body of the training session, and a cool-down with specifically prescribed intensities, volumes, and rest periods based on the goals of the training session (5). Additionally, Bompa and Buzzichelli classified short training sessions as lasting 30 – 60 min, medium length training sessions lasting 90 min to two hours, and long training sessions as lasting more than two hours (5). Considering practice time, competitions, travel, weight room schedule/availability, equipment, and educational requirements, it can easily be observed how time (or lack thereof) plays a role in determining what aspects of competitive sport will take priority. As a remedy, the practice of microdosing (MD) has recently gained traction in the field of sports performance. The following information provides an overview of what MD is, the limitations in utilizing it as a programming method, and the structure of an MD training session along with examples of in-season and off-season training microcycles.

MICRODOSING DEFINED

The concept of MD has its roots in the practice of pharmacology and relates to the "sub-pharmacological administration of an investigational drug" (21). The practice of MD in terms of physical development and sport performance was originally investigated in the military and team sport settings to determine the effectiveness of short, frequent workouts when time may be limited due to on-duty obligations and rigorous practice and competition schedules (10,19). In 2015, Kilen et al. examined physiological adaptations to short, frequent strength and endurance training sessions in a military setting (19). Their investigation concluded that MD training did not elicit any significant differences in adaptation when compared with longer, less frequent workouts throughout the week. Observations reported include a 6.5% increase in peak oxygen uptake, a 9% increase in muscular endurance, and an approximated 6 – 7% increase in isometric force of the knee extensors (19). More recently, Cuthbert et al. defined MD as, "the division of total volume within a micro-cycle, across frequent, short duration, repeated bouts" (10). Their research indicated improvements in upper- ($p<0.022$) and lower-body ($p<0.008$) strength; however, no distinct findings were reported between groups using MD training and those utilizing longer, less frequent workouts (10). Lastly, an online article by Hansen discussing speed and tempo training, introduced the concept to the sport of track and field (13). While the term MD and research into the training methodology are relatively new, the implementation of frequent training sessions to induce physiological change and, in turn, promote improvements in performance has been previously investigated with female athletes (12), weightlifters (14,20), American football players (17), and in the sport of bodybuilding (28).

A study by Häkkinen and Kallinen was one of the first to investigate the use of increased training frequency with sessions of shorter duration when compared with the traditional model of training (12). Their study investigated the distribution of daily training volume across two training sessions, as opposed to once per day. Häkkinen and Kallinen concluded that the distribution of volume across two training sessions per day yielded significant improvements in muscular hypertrophy and neuromuscular adaptations when compared with training once per day (12). As neuromuscular adaptations are a requisite component for improving power output, it may be concluded from the preceding findings from Häkkinen and Kallinen that power and hypertrophy can be improved via the use of MD programming (9). Furthermore, Cuthbert et al. concluded the MD approach utilizing more frequent, short duration training sessions throughout the week is equally as effective as a less frequent, longer workout approach to elicit improvements in muscular strength when the prescribed weekly volume-load was equated (10). In relation to improvements in muscular endurance, MD programming is still applicable. Because resistance training intensities are submaximal (<67% of one-repetition maximum [1RM]), the use of shortened rest periods may be implemented allowing for training to be completed in an interval or circuit fashion, and ultimately, a quicker time to completion for the training session (32).

CONTRAINDICATIONS AND LIMITATIONS OF MICRODOSING AS A PROGRAMMING METHOD

When considering the implementation of MD programming as part of a resistance training regimen, individual contraindications and limitations must be considered. Important items to consider include training age/status, emotional maturity, technical training needs, and injury history. "Training age" is a term borrowed from the Long-Term Athletic Development (LTAD) model and is defined as the amount of time an athlete has consistently followed a resistance training program (24). As a typical MD training session will be 15 – 20 min in length and is to last no longer than 30 min to keep the workout short, minimal time is available to be devoted to correctly teaching proper form and technique (13,18,19). In turn, challenges will arise when attempting to provide adequate safety to those athletes new to resistance training. Additionally,

with younger athletes, the strength and conditioning coach needs to consider individual growth and growth spurts, as these can affect prior levels of coordination, mobility, and flexibility (24). Furthermore, an increase in training frequency via MD has been shown to be more effective with athletes considered to be advanced in training status (5,17). In alignment with the recommendations for implementing MD programming in young athletes and those with little training experience, emotional maturity must also be considered. Past experiences dictate the influence of previous movement learned towards the resistance training tasks at hand could inevitably lead to more time being spent teaching and repeating prior coaching cues (29). Consequently, there is minimal time left to accomplish quality repetitions and, ultimately, little work is accomplished.

Further considerations for MD programming include having a set plan in place for when technical training will take place during the annual plan. Technical training is focused on developing sound and efficient movement quality that can then be transferred to the athlete's specific sport. Due to technique and new motor patterns being learned more efficiently when taught in parallel with other exercises (a concept known as differential learning), time spent teaching new lifts through use of the "repetition method" and focusing on a single movement pattern may be more time consuming and yield inferior results (3). Thus, this type of training may best be suited as its own workout to allow for the necessary time to devote to teaching and learning technical skills and sport-specific tasks.

Lastly, recent injury history must also be considered. As full neuromuscular control is inhibited post injury, after obtaining medical clearance, appropriate care and safety procedures must be followed to ensure baseline levels of strength and flexibility are returned to the athlete prior to full participation in a resistance training program (11). Due to the implements and methods used during exercises to promote improvements in neuromuscular control possibly being performed on uneven or unstable surfaces, and with varying levels of visual input, a time restraint should not be placed on athletes to ensure safety is maintained (27).

TRADITIONAL TRAINING FREQUENCY GUIDELINES

Traditional training programs are typically prescribed as weekly microcycles, which are then compiled and periodized to form the annual training plan. Weekly training frequency recommendations vary based on the training age of the individual athlete. The National Strength and Conditioning Association (NSCA) recommends the following number of training sessions per week based on an individual athlete's current training status: 2 – 3 sessions for beginners, 3 – 4 sessions for intermediate, and 4 – 7 sessions for advanced (32). In addition to weekly training session recommendations based on the current individual athlete training status, the NSCA has a frequency recommendation guide based on the specific phase of the competition calendar. Off-season athletes are recommended to train 4 – 6 times per week, pre-season athletes 3 – 4 times per week, in-season athletes 1 – 3 times per week, and post-season athletes 0 – 3 times per week (32). Lastly, overall physical stress encountered by the athlete from various forms of exercise and life stressors need to be accounted for to properly manage and plan for individual levels of fatigue.

While the preceding model is a suitable guide for training frequency prescription, other factors outside the control of the strength and conditioning coach and athlete could potentially hinder a well-thought-out plan. Possible unpredictable incidents that could alter a training plan include inclement weather, transportation and travel issues, athlete illness, family emergencies, and training space/equipment availability while traveling. If an individual or team sport athlete is following a traditional model of training, missed training due to any of the mentioned drawbacks may lead to suboptimal results. Poor outcomes will then be resultant of an insufficient training stimulus to elicit positive physiological adaptations. As MD uses shorter individual training sessions while dispersing the same amount of volume throughout the microcycle, there is a possibility that the adverse effect of a missed training session may be limited due to having the ability to schedule more training sessions throughout the week (10).

MICRODOSING – PROGRAMMING PRINCIPLES

WARM-UP

The warm-up is a commonly accepted component of each training session. Warm-ups are typically performed to prepare the body for training, while concurrently reducing the risk of injury (4). Moreover, the warm-up is typically 5 – 15 min in length and progresses from general movements to patterns that are more specific and closely mimic the activity or exercise to be performed (1,7). While a full warm-up may elicit improvements in lifting weights equal to and greater than 80% of 1RM, most training sessions will be performed with submaximal weights, thus not requiring the completion of both a general and specific warm-up (1). Furthermore, Barnes et al. suggested that a specific warm-up yields improvements in power output, lending to the conclusion that the general warm-up is not necessary to include in a structured training session when time is limited (4). Therefore, as has been suggested by prior studies investigating MD/time-efficient training, the warm-up for each MD training session may consist of a light, submaximal load for the first set of each movement (18,19).

MAIN BODY

The main body of the training session most often consists of 2 – 3 specific training objectives that are to be the primary focus (5). As previously mentioned, dependent upon the phase in the annual plan, MD programming allows for a focus on muscular endurance, hypertrophy, strength, and power. Additionally, separate training sessions to improve various aspects related to sport performance, including aerobic and anaerobic power, and speed, agility, and quickness (SAQ), may be scheduled apart from resistance training (13). In turn, the separation of resistance and sport performance training will allow the athlete ample recovery

time, which usually enables athletes to perform at a reduced level of fatigue. Improvements in each aspect of muscular adaptation may be achieved by employing the use of numerous methods. Table 1 includes a list of various methods and examples that may be employed as part of a MD training session to improve muscular endurance and hypertrophy (18,32).

Of particular importance in an MD training program is the use of compound, multi-joint movements. These movements allow for the simultaneous training of multiple muscle groups and stabilizers, thereby limiting the need to include single-joint, isolation movements (26). Both, the use of single-joint, isolation movements, and unilateral movements are contraindicated in MD programming due to the minimal amount of total work able to be accomplished concurrent with the amount of time necessary to devote to training each limb separately (18). Table 2 includes a list of major compound, multi-joint resistance training movements and derivatives classified as power and other core exercises, according to NSCA recommendations (32). Each exercise may be selected to serve as the foundation, or main movement, of the training session.

In terms of exercise order, those movements deemed as power exercises should be performed prior to other core exercises due to the amount of skill and coordination required to perform quality repetitions (31). In addition, those movements most often used to improve power output contribute to the largest amounts of fatigue during a training session (8,32). If no power exercises are included in the scheduled training sessions, then each workout can begin with a movement from the other core exercises list. To conclude an MD training session, supplementary or assistance pushing and pulling exercises that lend to overall improvements in exercises in the power and other core categories will be undertaken, as these movements require the least amount of energy and skill to perform. Tables 3 and 4 provide an example of in-season and off-season weekly microcycles utilizing MD, respectively. Table 5 provides a summary of the potential components that may be included in an MD program, dependent upon the results of the needs analysis for the sport.

TABLE 1. TIME-EFFICIENT TRAINING METHODS AND EXAMPLES

METHOD	EXAMPLE
Superset 2 exercises performed back-to-back stressing opposing muscle groups	Seated shoulder press x 10 repetitions Chin-up x 10 repetitions
Compound Set 2 exercises performed back-to-back stressing the same muscle group	Bench press x 12 repetitions Push-ups x 12 repetitions
Drop Set Perform 1 – 3 drops from load in initial set using a 20 – 25% reduction in intensity; each set performed to muscular failure	Set 1: Barbell back squat x 8 repetitions at 75% 1RM Set 2: 8 repetitions at 55% 1RM Set 3: 8 repetitions at 50% 1RM
Rest-Pause Perform multiple, consecutive sets to muscular failure at submaximal loads (<80% 1RM) prior to inter-set rest periods of 20 – 30 s until previously determined target number of repetitions is met	Safety bar squat at 70% 1RM, goal = 24 total repetitions Set 1: 12 repetitions (20 s rest) Set 2: 6 repetitions (20 s rest) Set 3: 4 repetitions (20 s rest) Set 4: 2 repetitions

TABLE 2. FOUNDATIONAL COMPOUND, MULTI-JOINT RESISTANCE TRAINING MOVEMENTS

POWER EXERCISES	OTHER CORE EXERCISES
	Squat variations
Snatch (from multiple positions) and high pull variations	Deadlift variations
Clean (from multiple positions) and high pull variations	Bench press and variations
Push jerk	Overhead press and variations
Push press	Chin-up/pull-up and variations
	Rowing variations

TABLE 3. EXAMPLE WEEKLY IN-SEASON MICRODOSING TRAINING STRUCTURE WITH 2 COMPETITIONS DURING THE WEEK

MONDAY
Ballistic/Plyometric, Strength and Power Focus (Morning)
Full court jog: x 3
A-skips-B-skips: 2 x 20 yards each
Pogo jumps: 2 x 10 yards
Barbell complex: shoulder press-RDL-bent over row-upright row: 2 x 5 repetitions each
Mid-thigh snatch high-pull: 3 x 3 at 55% 1RM
Barbell front squats: 3 x 3 at 85 – 90% 1RM
1-step approach box jumps (24 – 36" box): 3 x 2 each direction
Basketball Practice (Afternoon)

TUESDAY
Film/Walk-Through and Strength Focus (Morning)
Bodyweight squats: 2 x 10
Suspension trainer reverse lunges: 2 x 5 each leg
Hex-bar deadlift (concentric focus): 3 x 2 at 55 – 60% 1RM (estimated)
Dumbbell lateral lunge: 2 x 4 each leg
Dumbbell single-arm rows: 2 x 5 – 6 each arm
Game (Evening)

WEDNESDAY
Rest/Recovery/Regeneration
Basketball Practice (Afternoon) – No Training

THURSDAY
Ballistic/Plyometric, Strength and Power Focus (Morning)
Full court jog: x 3
Pogo jumps: 2 x 10 yards
Countermovement jump (continuous): 2 x 5
Barbell complex: shoulder press-RDL-bent over row-upright row 2 x 5 repetitions each
Mid-thigh hang clean: 3 x 3 at 75 – 85% 1RM
Barbell back squats: 3 x 3 at 90% 1RM
Band-assisted jumps: 3 x 4
Basketball Practice (Afternoon)

FRIDAY
Travel Day – No Practice or Training

SATURDAY
Game Day – Morning Film/Walk-Through – No Training

SUNDAY
Strength Focus (Morning)
Bodyweight push-ups: 2 x 10
Barbell inverted rows: 2 x 12
Resistance band high rows: 2 x 12
Seated dumbbell shoulder press: 3 x 4 – 5
Barbell bent over rows off safety pins (set at knee height): 3 x 3 – 4
Weighted chin-ups: 3 x 3
Basketball Practice (Afternoon)

TABLE 4. EXAMPLE WEEKLY OFF-SEASON MICRODOSING TRAINING STRUCTURE

MONDAY

Morning: (Power Focus)

50-yard jog – high knees 20 yards – walking lunge with side twist 20 yards – bounds 20 Yards x 2

Box jumps (24 – 36" box): 4 x 3 hurdle hops (3 – highest to lowest): 2 x 3

Barbell complex: shoulder press-RDL-bent over row-upright row 2 x 5 repetitions each

Mid-thigh clean: 6 x 3 at 65% 1RM

Afternoon/Evening: (Plyometric Focus)

A-skips-B-skips: 2 x 20 yards each

Stiff-legged pogo jumps: 2 x 5

Hurdle hops (3 – highest to lowest): 2 x 3
overhead medicine ball throw: 3 x 3

TUESDAY

Morning: (Strength Focus)

Suspension trainer rows: 2 x 12

Bench press: 2 x 5 (30 – 50% 1RM)

Barbell bench press (dynamic effort): 8 x 2 at 55% 1RM

Weighted chin-ups (eccentric focus): 3 x 4

Dumbbell shoulder press: 3 x 6

Dumbbell single-arm row: 3 x 4 each arm

Afternoon/Evening:

20 – 30 min foam roll/mobility exercises

WEDNESDAY

Morning: (SAQ Focus)

50-yard jog – high knees 20 yards – walking lunge with side twist 20 yards – bounds 20 yards x 2

30-yard sprints: 5 x 1 at 60 – 80% max effort

30-yard kneeling start sprints: 3 x 1 with each foot forward

Depth fall to vertical jump: 4 x 2

10-5-10 (acceleration-backpedal-acceleration): 4 x 1

Afternoon/Evening: (Power Focus)

Barbell complex: shoulder press-RDL-bent over row-upright row 2 x 5 repetitions each

Mid-thigh clean high pull: 5 x 2 at 55 – 65% 1RM

Barbell jump squat: 3 x 3 at 20 – 30% (of back squat 1RM)

Medicine ball slams (standing on 18 – 24" box): 3 x 3

THURSDAY

Morning: (Strength Focus)

Bodyweight squats: 2 x 10

Safety squat bar hand-supported squats: 6 x 2 (working up to 92 – 95% 1RM)

Barbell RDL: 4 x 3

Dumbbell reverse lunge: 3 x 3 each leg

Reverse hyperextension machine: 3 x 8

Afternoon/Evening:

20 – 30 min foam roll/mobility exercises

FRIDAY

Morning: (Plyometric Focus)

50-yard jog – high knees 20 yards – walking lunge with side twist 20 yards – bounds 20 yards x 2 stiff-legged pogo jumps: 3 x 10 yards

Countermovement jumps (continuous): 2 x 5

Depth jumps: 5 x 2

Triple jump: 3 x 3 (starting on each leg)

Band-assisted vertical jumps: 3 x 3

Afternoon/Evening: (SAQ Focus)

10-yard sprints: 3 x 1 at 60 – 80% max effort

10-yard sprints: 3 x 1 (with each foot forward) at max effort

40-yard sprints: 6 x 1 (3 with each foot forward) at max effort

Lateral shuffle to sprint (5-yard shuffle – 5-yard sprint): 3 x 1 each way

T-test: 2 x 2 (each direction)

SATURDAY

Morning: (Strength Focus)

Bodyweight push-ups: 2 x 12

Barbell shoulder press: 2 x 5 (30 – 50% 1RM)

Barbell push press: 5 x 2 at 80 – 85% 1RM

Isometric flexed elbow hang: 3 x 10 – 15 s

Rope attachment cable high rows: 3 x 6

Dumbbell farmer carry: 3 x 20 yards

Afternoon: No Training – Rest/Recovery

SUNDAY

No Training – Rest/Recovery

TABLE 5. SUMMARY OF POTENTIAL COMPONENTS TO INCLUDE IN AN MD PROGRAM BASED OFF NEEDS ANALYSIS RESULTS

POTENTIAL COMPONENTS TO INCLUDE IN AN MD PROGRAM
1. Muscular endurance, hypertrophy, strength, and power
2. Aerobic power
3. Anaerobic power
4. SAQ drills

COOL-DOWN

Many training sessions often conclude with a cool-down, consisting of several stretching and mobility exercises intended to improve rates of recovery, suppress delayed onset muscle soreness, and improve flexibility (5,18). However, some studies have illustrated that cool-downs may not have the intended effects and, overall, have little to no effect on improving sport performance (2,15,23,33). Therefore, if exercises performed while MD are performed through a full range of motion, resistance training may serve as a suitable replacement for static stretching (25,34).

CONCLUSION

Present day individual and team sport athletes face several different obstacles in their pursuit of optimizing sport performance. Limitations of time, space, or equipment, along with unforeseen events, including inclement weather, transportation, travel, illness, injury, and family emergencies, may limit an athlete's ability to prepare for competition. While traditional models of training provide a suitable means of preparation, training session length may be too long to suit the needs of many athletes. MD programming has been presented as a form of time-efficient exercise that allows for total volume to be dispersed over the course of short, multiple, daily training sessions. Consequently, adverse effects of missed training sessions can be minimized due to an increased number of opportunities to train during a weekly microcycle. Additionally, due to volume being distributed over the course of the day, as opposed to a single training session, fatigue levels may be minimized, theoretically allowing for greater recovery (13). Ultimately, movement intent and quality can be maximized leading to optimal physiological adaptations and, in conjunction with proper periodization, improvements in overall sport performance.

Prior to implementing MD programming, several considerations should be considered, including:

1. **Training Age/Experience**: Because MD training sessions typically last 15 – 20 min in length, an athlete classified as a beginner and relatively inexperienced with resistance training would not be well-suited to this method as minimal time is able to be devoted to teaching correct form and technique. Conversely, those athletes considered to be advanced in training status are better suited for MD.
2. **Emotional Maturity**: Those athletes that are unable to consistently direct their focus on training will accomplish little work during an MD training session due to constant re-direction and necessity to repeat coaching cues and instruction.
3. **Technical Training**: The inclusion of technical training in an MD program may be contraindicated as more time may be spent providing repetitive coaching cues to teach new movement patterns and ensure athlete safety.
4. **Injury History**: Due to the inhibition of full neuromuscular control post-injury, MD programming should not be applied during rehabilitation unless the athlete has first received medical clearance to do so.
5. **Unforeseen Obstacles to Training**: MD programming allows for the completion of numerous training sessions during the week, thereby minimizing the impact of missed workouts.
6. **Training Session Structure**: A MD training session will typically not include a warm-up or cool-down as part of its structure. Instead, the warm-up will be considered as the first submaximal set of each prescribed movement and the cool-down will be omitted as full range of motion resistance training may be an appropriate substitute for commonly employed static stretching routines (18,19,25,33).

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