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ORIGINAL ARTICLE

Attrition and Adherence Rates of Sustained vs. Intermittent Exercise Interventions

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Abstract
Background No conclusions have been drawn regarding the relative attrition and adherence rates associated with sustained vs. intermittent exercise programs.
Purpose The study aims to systematically examine randomized controlled exercise intervention trials that report attrition and/or adherence rates to sustained vs. intermittent aerobic exercise programs.
Methods A comprehensive literature search was conducted, and references from qualifying articles were searched for additional papers.
Results Fourteen articles met inclusion criteria, capturing 783 (76% female) enrolled and 599 (74% female) retained participants (mean age=42.3±6.6 years). Study durations ranged from 8 weeks to 18 months (mean duration=22.7±21.9 weeks). Although results varied, no consistent differences in attrition or adherence rates between sustained and intermittent exercise protocols were revealed.
Conclusions Given the universally low rate of regular exercise participation and the ongoing problem of adherence to exercise protocols, the field may benefit from randomized controlled trials examining sustained vs. intermittent exercise programs in greater depth.

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Introduction

Physical inactivity is one of the leading causes of preventable death in the USA, accounting for approximately 365,000 (15.2%) deaths, in the year 2000 [1]. Researchers predict that the combined effect of physical inactivity and poor nutrition will soon surpass smoking as the leading cause of preventable death if obesity rates continue to rise [1]. The percentage of US adults who regularly engage in the recommended amount of leisure-time exercise[1] is estimated at approximately 30.7% [3].

Although no recent epidemiological studies have examined exercise retention rates among previously sedentary individuals in the general population who begin an exercise program, numerous reports cite the statistic that 50% of people who start an exercise program will dropout within 6 months [4]. Individuals identify a variety of factors that prevent them from exercising, including a lack of one or more of the following: motivation, time, access to facilities or equipment, energy, workout partner, and self-efficacy [5–8]. Clearly, exercise interventions targeting sedentary individuals are warranted. Unfortunately, although numerous exercise interventions have been carefully designed and

[1] Although often used interchangeably, the terms physical activity and exercise technically describe slightly different concepts: Physical activity is defined as bodily movement produced by skeletal muscles that requires energy expenditure and produces progressive health benefits, whereas exercise is defined as a form of physical activity that is planned, structured, repetitive, and performed with the goal of improving health or fitness [2]. We consistently use the term exercise throughout this review despite the literature's interchangeable use of the two terms.

implemented [9–12], attrition rates in studies are high (25–50%), and participants who do complete these studies typically have low to moderate adherence rates with a mean of 66% [4]. A compounding problem is that adherence rates are difficult to accurately measure. Assessment methods include subjective measurements such as self-report inventories and exercise logs, objective measurements such as accelerometers and heart rate (HR) monitors, and observational measurements such as research assistants observing and recording the amount of exercise participants completed. Each of these methods has relative strengths and weaknesses in terms of accuracy, cost, resource availability, and feasibility, among others [2, 13–15]. These inherent measurement issues affect results of the individual studies for which they are utilized as well as comparisons of results across studies that utilize different methods, making collective conclusions about adherence rates difficult to draw.

Primary analyses of exercise intervention trials frequently concentrate on outcome goals, such as improvements in fitness and various measures of health status. Protocol adherence rates and other process goals are often reported as secondary or ancillary results in such studies or as the primary focus of additional publications. In contrast, comparisons of relative adherence rates to different types of exercise protocols in multi-group randomized controlled trials are rarely, if ever, the focus of research. However, process goals such as adherence rates are important to evaluate because even the best-designed exercise program will not improve participants' fitness and health status if attrition is high and adherence rates are low.

Traditional exercise interventions consist of sustained aerobic exercise (usually 20+min per session) completed 3–5 days per week throughout the duration of the intervention. This type of regimen aligns with exercise guidelines espoused by leading groups such as the American College of Sports Medicine (ACSM) [13] and Department of Human and Health Services [2]. However, this amount of sustained aerobic exercise can be overwhelming for individuals who are not only unfit but also short on time. Researchers have recognized the possibility of high attrition and poor adherence associated with these factors and attempted to alleviate them by modifying exercise intervention protocols to better accommodate participants. A commonly prescribed modified exercise intervention consists of multiple bouts of shorter duration aerobic exercise (typically two to three bouts of 10–15 min each per day). A major advantage of accumulated activity is its flexibility in terms of building short bouts of exercise into one's daily activities rather than setting aside a specific time of the day for exercise. In addition, unfit individuals may find short bouts of exercise less overwhelming and physically demanding than sustained exercise. As a result, they may be less likely to drop out and more likely to be adherent, particularly in the early phases of the program as they adjust to increased activity levels. Indeed, dropout rates are typically lower [14] and adherence rates higher [15] among previously sedentary or untrained individuals when the exercise prescription is moderate rather than vigorous.

Similar to the research on exercise interventions in general, studies on multiple short bouts of exercise typically focus on outcome goals. Results have indicated that multiple, short bouts of exercise are as effective as traditional, sustained exercise in terms of fitness and health status measures [16, 17]. This conclusion has been supported by several sources, perhaps the most convincing of which are direct comparisons of these types of exercise programs prescribed to individuals randomized to different groups within the same study, as evidenced by the results of a recent review paper [16]. The ACSM recognized the potential value of advocating for the division of sustained exercise in order to accommodate sedentary individuals' schedules and initially limited aerobic capacities. Its exercise guidelines recommend accumulating 150 min of moderate aerobic activity (or 110 min of intense aerobic activity) per week, regardless of whether the minutes are accumulated via five 30-min bouts, 15 10-min bouts, or any other combination that reaches the same overall weekly goal [17].

Intuitively, one might hypothesize that completion of and adherence rates to exercise interventions for sedentary individuals would be higher when exercise can be accumulated via multiple, intermittent bouts of activity as opposed to fewer, sustained bouts. However, to our knowledge, no published systematic review papers on this topic exist. Murphy et al. [16] recently published a review of outcome goals assessed in studies comparing sustained versus intermittent exercise prescriptions, but they did not address attrition and adherence rates. Therefore, the purpose of the current study is to thoroughly and systematically gather and examine all randomized controlled exercise intervention trials that report attrition and/or adherence rates for at least two types of exercise protocols: (1) traditional, sustained (20+min) bouts of aerobic exercise and (2) multiple, shorter bouts (5–15 min each) of aerobic exercise.

Methods

A literature search was conducted using the PsycINFO and PubMed databases with the following key terms: exercise OR physical activity AND adherence OR compliance. The only limitations specified were peer-reviewed journal articles written in English that included adults 18+years old. The PsycINFO and PubMed databases identified 565 and 131 articles, respectively, that met the search criteria. The entire lists of article titles were scanned for potential qualification. Abstracts of articles with titles that appeared

to address the topic of this review were examined, and full-text versions of papers that potentially qualified were located and evaluated for final inclusion. References from qualifying articles were subsequently searched for any potential additional papers, which were located and assessed for appropriateness.

Each study included in this review met the following criteria: (1) It directly compared outcomes related to two or more aerobic exercise programs, including at least one sustained (1×20+min per day) and one intermittent (multiple 5–15 min bouts, each separated by 2+h per day) program; (2) it was designed for and enrolled previously sedentary but otherwise generally healthy adults (18+years old); (3) its participants were assigned (e.g., randomized, stratified) into one of the different exercise programs; and (4) at least one measure of attrition and/or adherence to the exercise programs (e.g., overall completion rates, percentage of prescribed sessions or minutes completed, etc.) was reported, calculable, or feasible to determine by contacting the authors. If more than one article reporting various results from the same study was identified, only the one with the most adherence-related information was included in order to avoid double-counting studies and participants. If a study appeared to qualify but the identified paper associated with it was missing specific attrition or adherence information, the authors were contacted in attempt to obtain the necessary information.

The 14 qualifying articles were examined in-depth with the primary purpose of identifying all of the attrition and adherence information that was reported. Rather than attempting to conduct a meta-analysis of the heterogeneously reported data, the goal of this review was to qualitatively yet systematically describe and synthesize the information.

Using standard definitions to extract and/or calculate attrition and adherence rates across studies is important in a systematic review. However, doing so in this review was infeasible due to the inconsistent and often unexplained methods used to determine these rates. Nevertheless, we attempted to extract and/or calculate these rates as uniformly as possible to improve comparability across studies. When possible, our working definitions were as follows: Attrition was defined as the percentage of participants in each treatment group who did not complete the study (e.g., dropped out, not available for follow-up contact, unable to reach, etc.) in which they were enrolled according to the standards set forth by that study, and adherence was defined as the mean percentage of the exercise prescription that was completed by participants within each treatment group. Although individual studies differed in their methods of calculating adherence, they consistently captured completion of prescribed exercise, rather than attendance at exercise sessions or other definitions, in their reports or calculations. Therefore, our definition of adherence refers only to the exercise prescription when the intervention included multiple target behaviors. Participants who adhered to the exercise prescription were counted as adherent regardless of whether or not they adhered to other aspects of the intervention (e.g., diet plan, group meetings, check-in phone calls, etc.).

Results

Table 1 describes the 14 articles that met criteria for this review. A total of 783 participants (75.7% female) were enrolled in the studies, and 599 (73.7% female) completed them. Five studies [19–23] enrolled only females, one [24] enrolled only males, and the other eight [18, 25–31] enrolled both sexes. The mean age of participants was 42.3 (standard deviation=6.6)years. Mean ages were not reported uniformly across publications: Some were calculated based upon all enrolled participants whereas others were calculated based upon study completers only. However, only one article, which reported that dropouts were younger and heavier than completers at baseline [20], reported any significant differences between completers and dropouts in terms of age and other baseline demographics.

Studies varied widely in duration, ranging from 8 weeks [18, 24, 28] to 18 months [19, 20] with a mean of 22.7± 21.9 weeks. Ten studies randomly assigned participants to different groups, one [18] randomly assigned to sex-balanced groups, two [26, 27] "randomly allocated and stratified" participants to different groups based on sex and age, and one [23] assigned participants to different groups based upon their class schedules and availability. The number of different intervention arms per study ranged from two to four. Six of the studies [22, 23, 26–28, 31] incorporated a no-exercise control group. Exercise program characteristics varied widely across studies. Prescribed minutes per exercise session ranged from 5 to 15 among short/intermittent bouts exercise groups and from 20 to 40 among long/sustained bouts exercise groups. Prescribed numbers of bouts per day ranged from two to five (with 2+ to 4+ mandatory hours between each bout) among short/intermittent exercise groups, whereas only one bout per day was universally prescribed among long/sustained exercise groups. Four studies [19, 23, 25, 27] compared a long/sustained bouts group with two different short/intermittent bouts groups. In two of these studies [23, 27], the third group's exercise prescription was reminiscent of an intermediate/intermittent bouts type of plan (e.g., 2×15 min). One study [25] incorporated a third exercise arm that gave participants the freedom to choose their own exercise schedule in terms of minutes per bout and bouts per day as long as the total exercise added up to 30 min per day. The other study's [19] third arm participants' exercise prescription was identical to that of the short bouts group,

Table 1 Summary of qualifying papers

Article (authors, year) Objective of intervention	Subjects (randomized/completed); age (mean±SD)	Description of exercise intervention Description of other behavioral interventions incorporated into study	Patterns of exercise interventions	Study duration	Process measures used	Summary of results
Coleman et al., 1999 Objective: to evaluate 3 different ways to obtain 30 min of brisk walking per day, 6 days per week (the ACSM/CDC standards at the time of the study)	*N*=36 [sex not reported]/32 [27 females] sedentary individuals[a]; 39.9±8.6 years	Gradually raised goals, starting w/3 days/week → 4 days/week → 6 days/week Many other behavioral interventions, including goal setting and mastery, self-management techniques, weekly personal feedback during meetings with a study counselor, problem solving, and behavioral contracting	LB (*n*=12/10)—1×30 min/day SB (*n*=12/11)—3×10 min/day Choice (*n*=12/11): any combo adding up to 30 min/day	16- and 32-week follow-up	Adherence: subjects recorded exercise throughout each day in 5 min intervals; also wore accelerometers to verify self-report; also wore HR monitors for 3 walks in 1 week during 2 time points of intervention	Self-reported min of exercise (baseline, week 16, week 32): ns diff b/t groups in self-reported or accelerometer measured min but sig discrepancies b/t self-reported and accelerometer measured min for all groups (uniform discrepancies across groups); ns diff in HR (all groups 68–70% of predicted max)
Debusk et al., 1990 Objective: to evaluate the "threshold" of exercise duration required to produce training effects	*N*=40/36 sedentary or low active but otherwise healthy men; 51.5±6 years	5 days/week; home-based jogging program (65–75% of peak treadmill HR) No other behavioral interventions were incorporated, but a study staff member called subjects every 2 weeks to check progress, review logs, and answer questions	LB (*n*=20/18)—1×30 min/day SB (*n*=20/18)—3×10 min/day w/4+h b/t each bout	8 weeks	Adherence recorded daily and mailed to staff every 2 weeks; also recorded: HR and RPE during the last minute; overall level of enjoyment; level of convenience; whether sweating occurred	ns diff in attrition (2/20 dropped from each group); ns diff in adherence to # of sessions (LB 95% vs. SB 93%); ns diff in # of min adherence rates (LB 96% vs. SB 93% of prescribed 1,200 min); ns diff in %HR (LB 71% vs. SB 70%); ns diff in any other process measures
Jacobsen et al., 2003 Objective: to compare the effects of long-term (72 weeks) continuous vs. intermittent exercise on attrition and adherence in previously sedentary, moderately obese females	*N*=52/22 overweight/obese, sedentary females; 46±9.5 years	Supervised walking 3 days/week continuous (CON) @ 60–75% HRR OR home-based (2×/week randomly supervised) 5 days/week intermittent (INT) @ 50–65% HRR No other behavioral interventions were incorporated	CON (*n*=26/15)—1×30 min, 3 days/week INT (*n*=26/15)—2×15 min[b], 5 days/week, with at least 2 h between each bout	72 weeks	Attrition; adherence in terms of: distance walked, heart rate at the end of exercise, duration of exercise, and RPE	By design: INT > CON time and distance and INT < CON exercise %HR; ns diff in overall adherence (CON 93% vs. INT 84%); ns diff in attrition rates (11/26 completed each arm), but pattern of dropouts differed (sig diff in attrition for weeks 25–36 and 37–48); dropouts were younger and heavier in both arms; dropouts completed sig more weeks of INT [18] vs. CON [19]
Jakicic et al., 1995	*N*=56/52 sedentary, overweight/obese women; 40.7±6.6 years	Home-based exercise—5 days per week w/progressive min/day exercise as weeks went by (20 min/day→30 min/day→40 min/day); 70% HRR for both groups	LB (*n*=28/27)—1×20–40 min/day	20 weeks	Self-reported adherence (*n*=40) in terms of: days/week, min/session, sessions/week, and min/week; also collected objective	sig more days/week for SB vs. LB across all time periods of study; trend (p=0.08) toward greater min/week for SB vs. LB; by design, sig SB > LB sessions per week and SB < LB

Table 1 (continued)

Article (authors, year) Objective of intervention	Subjects (randomized/ completed); age (mean±SD)	Description of exercise intervention Description of other behavioral interventions incorporated into study	Patterns of exercise interventions	Study duration	Process measures used	Summary of results
Objective: to investigate whether prescribing exercise in several short bouts vs. 1 long bout per day would enhance adherence, cardiorespiratory fitness, and weight loss in overweight adult females enrolled in a behavioral weight control program		Weekly group-based behavioral sessions for 20 weeks, calorie-and fat-restricted diet, weekly exercise logs	SB (n=28/25)—2–4×10 min/day		data (n=44) using accelerometers worn for 2×5-day periods during intervention	min/session; sig diff in self-report > objective min for both groups but ns group diff; ns group diff in pattern of decline in weekly exercise after initial increase and peak levels
Jakicic et al., 1999	N=148/115 sedentary, overweight women; 36.7±5.6 years	Home-based exercise—5 days per week w/progressive min/day exercise as weeks went by (20 min/day → 30 min/day → 40 min/day); 70% HRR for all three groups	LB (n=49/37)—20–40 min sustained	18 months	Attrition rates; exercise participation in terms of accumulated min/week (self-report verified by accelerometer at various time points) and % attaining 150+min/week of exercise when program reached that level of exercise prescription (week 5)	ns diff in attrition rates among groups; sig more min/week among SB in weeks 1–4; ns diff in min/week in week 5 through month 12; sig more min/week among SBEQ in months 13–18; ns diff in % of participants w/in each group who accumulated ≥150 min/week throughout intervention; all groups declined after exercise peak: ns diff b/t groups in % decline in min/week during months 7–12, but SB declined sig more than SBEQ in months 13–18; ns diff in self-report vs. objective exercise min/week
Objective: to compare the effects of intermittent with traditional continuous exercise on weight loss, adherence, and fitness and to examine the effect of combining intermittent exercise with home exercise equipment		Behavioral weight control program w/frequent group treatment meetings focused on behavioral strategies for modifying eating and exercise behaviors; instructed to reduce daily energy and fat intake; recorded dietary intake and received nutrition-related feedback	SB (n=51/36)—2–4×10 min/day SBEQ (n=48/42): same as SB and given treadmills to use at home			
Macfarlane et al., 2006	N=50 [35 females]/45 [30 females] sedentary adults; 48.7±6.9 years	Structured EPM vs. LIFE activity group, each to accumulate 10–11 MET h per week (EPM total of 78 MET h [range 60–96] and LIFE total of 90 MET h [range 80–100] LMPA)	EPM (n=25/25)—30 min sustained LMPA (5–6 METs) 3–4 days/week	8 weeks	Attrition rates; adherence in terms of time, duration, mode, RPE; checked with accelerometer 1 full day per person	sig diff in attrition rates: all dropouts [5] and non-completers [1] from LIFE group; ns diff b/t groups on adherence rates w/ 3 in each group failing to meet program standards; LIFE=40 vs. EPM=29 days active (goals 40 vs. 28); ns diff b/t MET h: EPM=163.0 [89.6] MET h vs. LIFE=148.2 [71.6] MET h
Objective: to examine whether accumulating short intermittent bouts of light-to-moderate physical activity can elicit significant improvements in the fitness of sedentary adults, compared to 1 longer continuous bout	Note: Study participants were randomly assigned to 2 sex-balanced groups	no other behavioral interventions were included, but participants were instructed to complete a daily log for each bout of activity (time, duration, mode, and rating of perceived exertion)	LIFE (n=25/20)—5 daily bouts of 6 min (30 min total) LMPA (3–4 METs) 5 days/week			

Table 1 (continued)

Article (authors, year) Objective of intervention	Subjects (randomized/ completed); age (mean±SD)	Description of exercise intervention Description of other behavioral interventions incorporated into study	Patterns of exercise interventions	Study duration	Process measures used	Summary of results
Murphy and Hardman, 1998 Objective: to test whether similar improvements in endurance fitness and decreases in body fatness and SBP can be achieved through several short bouts of brisk walking per day vs. 1 longer continuous bout, in sedentary women	*N*=47/34 sedentary (not obese) women; 44.4± 6.2 years	5 days per week moderate walking done at university campus (1 day per week supervised) @ 70–80% maximal HR No other behavioral interventions were incorporated into this study	LB (*n*=16/12)—1×30 min/day SB (*n*=16/12)—3×10 min/day w/4+h b/t each session Usual lifestyle control (*n*=15/10)	10 weeks	Adherence rates in terms of: accumulated minutes, % of prescribed exercise sessions, and %HR (determined w/ HR monitor at each session)	ns diff in total min walk time; ns diff in adherence to # of prescribed sessions (LB 88% vs. SB 85%); ns diff in %HR (LB 75% vs. SB 73%); ns diff b/t groups in attrition (4 LB, 4 SB, 5 control dropouts)
Murphy et al., 2002 Objective: to compare the effects of different patterns (short intermittent bouts vs. 1 longer continuous bout) of regular brisk walking on aerobic fitness, risk factors for cardiovascular disease, and indices of psychological well-being in previously sedentary adults	*N*=32 [20 females]/ 21 [14 females] sedentary individuals; 44.5± 6.1 years	5 days per week moderate walking done at university campus (1 day per week supervised) @ 70–80% maximal HR determined w/ HR monitor at each session No other behavioral interventions were incorporated into this study	2 groups crossover design w/ 2 week washout period: LB (1×30 min)→ SB (3×10 min w/3+h b/t each session) (*n*=16/8) SB (3×10 w/3+ h b/t each session) → LB (1×30 min) (*n*=16/13)	14 weeks total (6 weeks× 2 w/ 2-week washout period)	Adherence rates in terms of accumulated minutes, % of prescribed sessions, and %HR	ns diff adherence to walking time SB 88.2% vs. LB 91.3%; ns diff # of days active SB 28.3 vs. LB 27.5; ns diff min/week SB–LB vs. LB–SB; higher dropout rate (4 vs. 0) in second phase for LB–SB and higher dropout rate overall (7 vs. 2) for LB–SB; 2 subjects (1 vs. 1) failed to meet 60% compliance and were considered non-completers; ns diff in adherence rates: SB–LB 92.6–90.9% vs. LB–SB 85.1–86.2%
Murtagh et al., 2005 Objective: to examine the effect of instructing sedentary individuals to undertake 20 min of brisk walking, in 2 different patterns, 3 days per week, on fitness and other cardiovascular disease risk factors	*N*=48 [32 females]/ 32 [17 females] sedentary individuals; 45.7± 9.4 years	3 days per week walking; advised participants to exercise on treadmills and provided them free of charge on campus lab; once per week supervised No other behavioral interventions were incorporated into this study	No tx control (*n*=11/8) SINGLE (*n*=19/15)—1×20 min/day ACC (*n*=18/9)—2×10 min/day	12 weeks	Adherence rates; attrition rates; intensity and RPE during exercise	sig diff in dropout rates (3 controls, 3 SINGLE, 8 ACC=16% vs. 16% vs. 44%); 2 subjects (1 SINGLE, 1 ACC) failed to meet 60% compliance and were treated as non-completers; ns diff in completers' adherence rates SINGLE 90.4% vs. ACC 82.1% of prescribed min; ns diff in intensity or RPE

Table 1 (continued)

Article (authors, year) Objective of intervention	Subjects (randomized/ completed); age (mean±SD)	Description of exercise intervention Description of other behavioral interventions incorporated into study	Patterns of exercise interventions	Study duration	Process measures used	Summary of results
Osei-Tutu and Campagna, 2005 Objective: to determine the effects of short vs. long bouts of physical activity on mood, VO_2 max, and body composition	*N*=40 [19 females]/ 30/[15 females] healthy, sedentary individuals; 34.3± 5.6 years	Progressive 3→4→5 days per week home-based brisk walking @ 60–79% VO_2 max (reassessed frequently) No other behavioral interventions were incorporated into this study	No tx control (*n*=10/10) LB (*n*=15/11)—1×30 min/day SB (*n*=15/9)—3×10 min/day w/2+h b/t each bout	8 weeks	Attrition rates; did not report breakdowns of adherence rates; also collected mood data at regular time points throughout study to assess psychological changes	Before study began, 2 LB and 1 SB males decided to not participate b/c of time demands; 5 dropouts in SB vs. 2 dropouts in LB throughout remainder of the study duration
Quinn et al., 2006 Objective: to determine whether an incremental 12-week intermittent exercise program yielded improvements in health-related variables similar to benefits from a 12-week continuous exercise program; a secondary purpose was to see if these health-related improvements could be maintained or improved when switching from 1 program to the other	*N*=45 [sex not reported]/37 [20 females] inactive individuals; 48.8± 9.0 years	4 days per week home-based exercise program; 30 min/ day; incremental increase in intensity (50–60%, 60–70%, 70–80% HRR) No other behavioral interventions were incorporated into this study; notably, participants were allowed to choose any exercise modality as long as they achieved their frequency, time, and intensity goals	2 group crossover design: CON (*n*=22/17)—1×30 min/day INT (*n*=23/20)—2×15 min/day w/4+h b/t bouts	24 weeks (12 weeks in each intervention arm)	Attrition rates; adherence rates in terms of min/week, % of prescribed min, and %HRR during exercise	ns diff in attrition rates (5 CON vs. 3 INT); ns diff in adherence to prescribed min CON 96.6% vs. INT 96.3%; ns diff in accumulated min/ week; ns diff in %HRR during exercise (instructed to start counting toward exercise min when goal HR achieved)
Schmidt et al., 2001 Objective: to compare the effect of monitored exercise programs differing in daily frequency and exercise bout duration on aerobic fitness and weight loss during a period of caloric restriction	*N*=48/38 overweight, sedentary, female college students; 19.7±1.4 years Note: This study assigned participants to groups based on class schedule and availability	Lab-based, supervised exercise program w/stationary bicycle; total exercise duration progressed from 15 to 30 min/day, 3–5 days per week; 75±5% HRR, recalculated weekly Phone calls/emails for missed sessions; PI contact if necessary; self-monitored, calorie-restricted diet w/ 2 nutrition classes	Control (*n*=12/8) 1B (*n*=12/12)—1×15–30 min/day 2B[c] (*n*=12/10)—2×15 min/day 3B[c] (*n*=12/8)—3×10 min/day	12 weeks	Attrition; adherence in terms of days/week	sig chi square diff b/t% of subjects who dropped out in 1B, 2B, 3B groups, respectively (0% vs. 17% vs. 33%); ns diff in days/week (groups means 3.7–3.9); all 3 groups' adherence levels declined sig as weeks progressed, but no sig diff b/t groups in levels of decline; participants in 2B and 3B groups sometimes completed bouts late at night if their schedules required such modifications

Table 1 (continued)

Article (authors, year) Objective of intervention	Subjects (randomized/completed); age (mean±SD)	Description of exercise intervention Description of other behavioral interventions incorporated into study	Patterns of exercise interventions	Study duration	Process measures used	Summary of results
Woolf-May et al., 1998 Objective: to examine whether a moderate-intensity exercise regimen, carried out in short bouts throughout the day, would produce benefits similar to that of a regimen consisting of 1 longer bout of daily exercise of similar intensity and total duration, focusing on potential changes in aerobic fitness, blood lipids/proteins, and fibrinolytic activity	*N*=62 [31 females]/49 [21 females] sedentary or low active individuals; 55.8±8.3 Note: Groups were randomly allocated and stratified based on gender and age, then maneuvered to accommodate couples, etc.	Home-based walking program (optional weekly supervised walking) progressing from 60 min/week to 200 min/week by week 12; 70–75% predicted VO_2 max No other behavioral interventions were incorporated into this study	Control (*n*=17/16) LB (*n*=22/17)—1×20–40 min/day SB (*n*=23/16): up to 3×10–15 min/day w/120+min b/t each bout (minimum of 10 min/bout, maximum of 3 bouts per day)	18 weeks	Attrition rates; adherence rates in terms of total minutes throughout entire program, mean min/week, and mean HR/%HRR	ns diff in attrition rates; ns diff in total min of exercise time throughout entire study; ns diff in mean min of exercise time per week; ns diff in mean HR or %HRR (LB 73% vs. SB 71.3%)
Woolf-May et al., 1999 Objective: to further investigate the effects of single and accumulated short bouts of walking upon aerobic capacity and blood lipid profile	*N*=79 [54 females]/56 [37 females] sedentary individuals; mean age not reported (range 40–66 years) Note: 4 groups stratified via random allocation considering age and gender	Home-based walking program (optional weekly supervised walking) progressing from 60 min/week to 200 min/week by week 9; 70–75% predicted VO_2 max Optional weekly supervised walking sessions; 2 newsletters sent to maintain motivation; phone calls; contact number provided to subjects in case they needed help or info	Control LB=1×20–40 min/day IB=2–3×10–15 min/day SB=3–4×5–10 min/day Individual group *n*'s not reported and unable to locate by study authors (contacted via email to retrieve information)	18 weeks	Adherence rates in terms of total minutes walked throughout study duration, min/week (total and final weeks), and mean HR/%HRR	Which groups had dropouts was not reported; ns diff in total min of exercise time throughout entire study; ns diff in mean min/week total or in final 10 weeks; ns diff in HR or % HRR

ACSM American College of Sports Medicine, *CDC* Centers for Disease Control and Prevention, *HR* heart rate, *RPE* rate of perceived exertion, *HRR* heart rate reserve, *MET* metabolic equivalents, *LB* long bouts, *SB* short bouts, *SBEQ* short bouts w/exercise equipment, *EPM* exercise prescription model, *LIFE* lifestyle, *LMPA* light-to-moderate physical activity, *SINGLE* single bouts, *ACC* accumulated bouts, *CON* continuous exercise first, *INT* intermittent exercise first, *1B* one bout, *2B* two bouts, *3B* three bouts

[a] Three dropouts before study began and one within first week of intervention

[b] Note: Intermittent exercise participants were given the choice b/t 2×15 and 3×10 min, and all chose 2×15 min

[c] Bouts were separated by 4+h

but this group of participants also received free exercise equipment (treadmills) to use at home throughout the study. Two studies [29, 30] utilized a two-group crossover design, whereby half of their participants were initially prescribed intermittent followed by sustained exercise and vice versa. One of these studies [30] incorporated a 2-week washout period during which participants were instructed to cease exercise before beginning the other type of exercise program.

Twelve studies prescribed the same total number of minutes per day and days per week of exercise to each of its groups, divided differently according to group. The two other studies [18, 20] intentionally prescribed more days and minutes per week to the intermittent exercise group than to the sustained exercise group for non-adherence-related reasons. We considered whether or not these two studies were appropriate for this review given their unequal exercise prescriptions but decided to include them for three reasons. First, these two studies met the a priori criteria for review inclusion, which did not include a requirement addressing this issue. Second, all of the included studies were heterogeneous in many respects, so this difference is just one of many. Finally, most of the studies required participants to warm up and cool down at the beginning and end of each exercise session but instructed them to not count these extra minutes of exercise toward their totals. In effect, adherent intermittent exercisers in many of the other studies were essentially prescribed more total minutes of activity than adherent sustained exercisers due to their additional opportunities for warm-up and cool-down minutes before and after each exercise bout.

The stated primary purpose of virtually all of the studies was to evaluate outcome goals such as weight loss and/or health status (e.g., fitness levels, diabetes control, cholesterol or blood pressure reduction) improvements associated with the different types of exercise prescriptions. Overall, the included studies did not find consistent, significant differences between the various types of exercise prescriptions in terms of the outcome goals they examined [16]. However, the six studies that included a control group that received no-exercise intervention generally found significant improvements in outcome variables among all exercise groups compared to the no-treatment control groups [22, 23, 26–28, 31].

The 14 articles typically reported attrition and/or adherence rates as secondary or ancillary process goals, reflecting the primary and secondary purposes of the studies on which they were based. However, three articles [19–21] specifically focused on attrition and adherence rates. Jacobsen et al.'s article [20] focused solely on attrition and adherence rates; however, an earlier publication associated with the same study [32] examined physiological outcome goals, which comprised the primary purpose of the study. The two other articles [19, 21], which were written by the same research group about analogous studies, simultaneously focused on process (attrition and adherence rates) and outcome (weight loss and cardiorespiratory fitness) goals.

Attrition and adherence rates were not reported uniformly in the qualifying articles, making a meta-analysis impractical, if not impossible. A few articles did not explicitly state these rates but at least contained participation numbers from which attrition and/or adherence rates were calculable. One article [28] only contained the numbers of dropouts in each group (from which attrition rates were calculable) but did not report any adherence rates or numbers. Another publication [27] reported adherence rates but did not contain enough numbers to make attrition rates reliably calculable; its authors were contacted in attempt to obtain these numbers, but they were unable to locate the necessary information.

Attrition rates of the 13 of 14 studies that reported attrition information ranged from 7% [21] to 58% [20]. Three studies reported statistically significantly higher attrition rates of intermittent vs. sustained exercise arms [18, 23, 31]. One study reported statistically significant differences between its treatment arms' attrition rates at two time points throughout the study and a shorter time until dropout among long vs. short bout participants, but it found no overall between-group difference in attrition rate [20]. Furthermore, one of the crossover design studies reported a higher dropout rate among participants in the long bout crossing to short bout group than the short bout crossing to long bout group [30]. However, as mentioned before, these percentages were not defined consistently across studies included in this review. For example, some researchers considered participants retained if they attended the post-intervention or follow-up testing session (regardless of their exercise participation level), some only counted participants as retained if they completed a minimum number of total prescribed exercise sessions or minutes, and others did not clearly explain what method they used to calculate attrition rates or count dropouts.

Likewise, methods of calculating adherence rates varied widely across studies. Some included all enrolled participants (i.e., intent-to-treat analyses), whereas others included only retained participants (i.e., per protocol analyses) in their calculations. The potential problems associated with combining data among studies that employed various adherence rate calculation methods were compounded by the inconsistent methods used to determine attrition rates. Moreover, studies calculated adherence rates using data collected from various types of assessment tools, including subjective, objective, and behavioral observation methods. As discussed earlier, these different types of measurements frequently impact adherence results.

Nevertheless, most studies reported mean numbers of completed versus prescribed minutes of exercise or mean percentages of prescribed minutes completed according to group. Many also reported HR data because participants were instructed to reach and maintain minimum levels or ranges of heart rate reserve or maximal oxygen consumption (VO_2 max) percentages during each exercise session. All studies collected self-reported exercise data, and most also collected objective data to verify at least a portion of self-reported data via a combination of accelerometers [18, 19, 21, 25], HR monitors [22, 23, 25–27, 29, 30], and/or observed/supervised exercise sessions [22, 23, 26, 27, 30, 31]. None of the 14 studies found a statistically significant difference between sustained and intermittent exercise groups' adherence rates that was sustained over the course of the entire study. However, one study found a difference between groups only at certain assessment points but not others [19], and another study reported a marginally significant trend [21]. The lack of an overall treatment by time difference across studies was regardless of whether adherence was reported in terms of completed versus prescribed minutes per session, minutes or sessions per week, total sessions or minutes throughout the intervention, or target HR,% heart rate reserve, or %VO_2 max.

Discussion

Overall, this review did not find evidence that attrition or adherence rates differ between sustained and intermittent exercise prescriptions for previously sedentary, generally healthy adults without previously diagnosed major medical problems enrolled in exercise intervention studies that directly compared these two types of exercise programs. A notable finding of this review was the paucity of research addressing this topic. Indeed, although 14 identified studies contained (some of them barely) sufficient information to examine this question, only three of these papers [20] specifically focused on it. Of those three papers, two [26, 27] simultaneously addressed outcome measures, and the third [20] was a secondary paper written about a study designed with the primary purpose of examining physiological outcomes [32]. Given the universally low rate of regular exercise participation [3] and the ongoing problem of adherence to exercise protocols in research studies, the field would benefit from randomized controlled trials designed specifically to directly compare attrition and adherence rates of sustained vs. intermittent exercise prescriptions.

Attrition

The wide range of attrition rates (7–58%) was not associated with exercise protocol (e.g., minutes per day or days per week, % heart rate reserve, etc.) or any other obvious differences between studies. However, many of the studies had broader goals, such as weight loss [19, 21, 23], mood and psychological health enhancement [28, 30], and cardiovascular risk reduction [22, 26, 27, 30, 31], and associated behavioral intervention components designed to enhance the exercise prescription. Upon scrutiny, five of the 14 studies' attrition rates were atypical: Four studies retained high percentages of enrolled participants for this type of research, at 88% [25], 90% [18, 24], and 93% [21], and one [20] retained a relatively low 42%. The other nine studies' attrition rates were quite cohesive, with a range of 18–34%, and consistent with the range of attrition rates (25–50%) reported in the literature on exercise interventions in general [6].

We decided to look deeper into the characteristics of the studies with atypical attrition rates since they constituted more than one third of this review and could contribute valuable information to future research. As shown in Table 1, Coleman et al.'s 16-week (with a 32-week follow-up) study [25] had a low 12% attrition rate, including three dropouts of enrolled participants prior to the start of the study and one participant during the first week of the study. This intervention included many other components that may have contributed to the low attrition rate, such as goal setting and mastery, self-management techniques, weekly personal feedback during meetings with a study counselor, problem solving, and behavioral contracting. Similarly, Jakicic et al. [21] retained 93% of their participants in a 20-week program that included weekly group-based behavioral sessions, a calorie- and fat-restricted diet, and weekly exercise logs. However, Debusk et al. [24] retained 90% of their enrolled participants in a much shorter 8-week study that did not include other behavioral interventions but did incorporate bi-weekly calls to participants in order to check their progress, review their logs, and answer their questions. Likewise, Macfarlane et al. [18] retained 90% of their participants in an 8-week program that only incorporated exercise self-monitoring in the form of detailed daily logs (time, duration, mode, and rating of perceived exertion) for each bout of activity. In contrast, 58% of participants in Jacobsen et al.'s study [20], which did not include any other behavioral components, dropped out by the end of its relatively long 72-week duration.

Two clear differences between the high attrition [20] and low attrition studies [18, 21, 24, 25] were their durations (72 weeks for the high attrition study vs. 8 to 20 weeks for the low attrition studies) and supplemental behavioral components (none in the high attrition study vs. at least self-monitoring and a variety of other behavioral components in the low attrition studies). The combination of a minimal intervention (i.e., exercise prescription only) and

long duration (18 months) may explain the high attrition rate of the Jacobsen study [20]. These characteristics made it more similar to a prospective observational study than a randomized intervention trial and, in effect, confirmed something well-known in the literature: Adhering to an exercise prescription is difficult for a majority of individuals to maintain over time, particularly when the exercise prescription is not combined with a comprehensive behavioral program. In contrast, the only other 18-month study in this review took place in the context of a comprehensive behavioral weight control program that provided high levels of individual and group support [19]. Nearly 78% of the initial 148 participants in that study were retained, suggesting that exercise maintenance may be highly dependent upon ongoing motivation and support.

On the other hand, the combination of short durations and at least one other behavioral component may account for the low attrition rates of the two aforementioned 8-week studies [18, 24]. Likewise, the other two studies with low attrition rates [21, 25] were considerably shorter (20 and 16 weeks, respectively) and more comprehensive than the Jacobsen study [20]. The eight other studies with more typical attrition rates had a considerable range in terms of study duration (ranging from 8–24 weeks) and behavioral intervention components (six had no other components and two had a variety of them). Thus, although our findings suggest that shorter study length and supplemental behavioral intervention components may contribute to lower attrition rates, patterns are difficult to reconcile and require further research.

Adherence

Most of the studies' mean adherence rates for both intermittent and sustained exercise groups were considerably higher than the overall mean adherence rate (66%) reported in the literature on exercise interventions in general [4]. A few potential explanations may underlie these findings. For example, many of the research teams calculated adherence rates using per protocol rather than intent-to-treat analyses. This method may have artificially inflated these studies' adherence rates. Moreover, some researchers calculated adherence rates by including only participants who completed a minimum percentage of the protocol, making their computations circular. Another potential explanation is that the other components of many studies' behavioral interventions maintained participants' interest and motivation. This theory is supported by the relatively high retention rates of even the no-exercise control group participants in studies that included a control group.

Contrary to our hypothesis, no consistent, significant differences in adherence rates between sustained and intermittent exercise groups were observed in the papers included this review. However, one study [21] reported a significantly higher mean number of days per week and a trend (p=0.08) toward more mean minutes per week of exercise among the short bouts vs. long bouts group. Additionally, Jakicic et al. [19] calculated adherence rates at multiple times throughout the study's duration and found significant differences between groups during two random time periods, but their overall findings suggested no consistent pattern of differences.

Further, one of the two studies that employed a two-group crossover design [30] reported a higher attrition rate overall, particularly in the crossover phase of the study, among participants who started in the long bouts group and crossed over to the short bouts group. Collectively, the findings from these three studies [19, 21, 30] suggest that sedentary individuals may be more likely to stick to an exercise program if the sessions are initially less challenging (i.e., intermittent bouts) but gradually become more physically demanding (i.e., sustained bouts).

However, the other study that employed a two-group crossover design [29] did not find any significant differences in attrition or adherence rates between groups. Results from this study neither support nor refute the hypothesized potential advantage of initially prescribing short bouts and gradually transitioning to longer bouts of exercise in order to increase adherence, but they do raise doubt about the theory, particularly since the evidence was already weak at best.

Limitations

Because this review was qualitative, it was able to capture rich, descriptive information about attrition and adherence rates as well as specific, unique patterns found within individual studies. Our review of the existing literature led us to conclude that it does not contain enough standardized information on this topic to allow for a quantitative meta-analysis at this time. The qualifying studies were overwhelmingly heterogeneous, particularly in terms of overall purpose, methodology, intervention intensity and duration, and data collection, analysis, and synthesis.

This review excluded studies that only evaluated either a sustained or an intermittent exercise prescription compared to a control group rather than directly comparing the two types of exercise prescriptions within the same study. Including studies that only directly compared the two types of prescriptions considerably narrowed the range of studies that could provide important attrition and adherence information. The primary rationale for examining only articles based on studies directly comparing both types of exercise inter-

ventions was to minimize differences between studies *aside from* the exercise prescription types. For example, many exercise studies incorporate additional behavioral components into their interventions, as evidenced by many of the studies included in this review. Other potentially important differences that may have made comparing studies with either one or the other type of exercise intervention unwise include the following: participant demographics (e.g., age, sex, race/ethnicity, socioeconomic status, health status, motivation levels), study location, researcher characteristics (e.g., age, sex, race/ethnicity, education, devotion of time and energy to study, ability to motivate participants, personality differences), match/connection between research team and participants, and length of intervention, among others. Considering the heterogeneity of the studies already included in this review, adding even more variation by including studies with either one or the other type of exercise intervention versus a control group would have been untenable.

Finally, publication bias may have played a role in the findings of this review. Specifically, significant results are more likely than non-significant results to be published in peer-reviewed journals; likewise, interventions that are considered unsuccessful due to high attrition and/or low adherence are less likely to be published. Thus, other interventions that have directly compared sustained versus intermittent exercise prescriptions but reported high attrition and/or low adherence and results from such studies that found non-statistically significant differences between the two types of interventions may exist but remain unknown to the scientific community.

Summary

In sum, this review did not find evidence to support the notion that attrition rates of or adherence rates to exercise protocols differ between programs prescribing long/sustained vs. short/intermittent bouts multiple times per day among previously sedentary, generally healthy adults without previously diagnosed major medical problems. Randomized controlled trials specifically examining this issue in greater depth are warranted. Furthermore, interventions comparing sustained and/or intermittent exercise with another prescription beginning with intermittent exercise and progressing to sustained exercise might help to clarify the hypothesis that this gradual increase in exercise might increase retention and adherence. Finally, other studies might advance the field by randomizing participants to choice of exercise prescription (intermittent or sustained) or assigned exercise prescriptions to investigate whether adherence is more related to individual preference than general acceptability.

Conflict of Interest Statement The authors have no conflicts of interest to disclose.

References

1. Mokdad AH, Marks JS, Stroup DF: Actual causes of death in the United States, 2000. *JAMA.* 2004, *291:*1238–1245.
2. US Department of Health and Human Services (USDHHS): *2008 physical activity guidelines for Americans*. Washington, DC: USDHHS, 2008.
3. Schoenborn CA, Adams PF: Health behaviors of adults: United States, 2005–2007. *Vital Health Stat.* 2010, *10 (245)*.
4. Dishman RK: *Exercise adherence: Its impact on public health*. Champaign: Human Kinetics Books, 1988.
5. King A, Castro C, Wilcox S, et al: Personal and environmental factors associated with physical inactivity among different racial-ethnic groups of U.S. middle-aged and older-aged women. *Health Psychol.* 2000, *19:*354–364.
6. Chinn D, White M, Harland J, et al.: Barriers to physical activity and socioeconomic position: Implications for health promotion. *J Epidemiol Community Health.* 1999, *53:*191–192.
7. Ryan R, Frederick C, Lepes D, et al: Intrinsic motivation and exercise adherence. *Int J Sport Psychol.* 1997, *28:*335–354.
8. Trost S, Owen N, Bauman A, et al.: Correlates of adults' participation in physical activity: Review and update. *Med Sci Sports Exerc.* 2002, *34:*1996–2000.
9. Kahn EB, Ramsey LT, Brownson RC, et al.: The effectiveness of interventions to increase physical activity: A systematic review. *Am J Prev Med.* 2002, *22:*73–107.
10. Task Force on Community Preventive Services: Recommendations to increase physical activity in communities. *Am J Prev Med.* 2001, *22(suppl):*67–72.
11. Hillsdon M, Foster C, Thorogood M: Interventions for promoting physical activity. *Cochrane Database Syst Rev.* 2005, *CD003180*.
12. Blamey A, Mutrie N: Changing the individual to promote health-enhancing physical activity: The difficulties of producing evidence and translating it into practice. *J Sports Sci.* 2004, *22:*741–754.
13. Haskell WL, Lee IM, Pate RR, et al.: Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Medicine & Science in Sports & Exercise.* 2007, *39:*1423–1434.
14. Blair SN, LaMonte MJ, Nichaman MZ: The evolution of physical activity recommendations: How much is enough? *Am J Clin Nutr.* 2004, *79:*913S-920S.
15. Perri M. G., Anton SD, Durning PE, et al.: Adherence to exercise prescriptions: Effects of prescribing moderate versus higher levels of intensity and frequency. *Health Psychology.* 2002, *21:*452–458.
16. Murphy MH, Blair SN, Murtagh EM: Accumulated versus continuous exercise for health benefit: A review of empirical studies. *Sports Med.* 2009, *39:*29–43.
17. Pollock ML, Gaesser GA, Butcher JD, et al.: ACSM position stand: The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. *Medicine & Science in Sports & Exercise.* 1998, *30:*975–991.
18. Macfarlane DJ, Taylor LH, Cuddihy TF: Very short intermittent vs continuous bouts of activity in sedentary adults. *Preventive Medicine.* 2006, *43:*332–336.
19. Jakicic JM, Winters C, Lang W, Wing RR: Effects of intermittent exercise and use of home exercise equipment on adherence, weight loss, and fitness in overweight women: A randomized trial. *JAMA: The Journal of the American Medical Association.* 1999, *282:*1554–1560.

20. Jacobsen DJ, Donnelly JE, Snyder HK, Livingston K: Adherence and attrition with intermittent and continuous exercise in overweight women. *International Journal of Sports Medicine.* 2003, *24:*159–164.
21. Jakicic JM, Wing RR, Butler BA, Robertson RJ: Prescribing exercise in multiple short bouts versus one continuous bout: Effects on adherence, cardiorespiratory fitness, and weight loss in overweight women. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity.* 1995, *19:*893–901.
22. Murphy MH, Hardman AE: Training effects of short and long bouts of brisk walking in sedentary women. *Med Sci Sports Exerc.* 1998, *30:*152–157.
23. Schmidt WD, Biwer CJ, Kalscheuer LK: Effects of long versus short bout exercise on fitness and weight loss in overweight females. *J Am Coll Nutr.* 2001, *20:*494–501.
24. DeBusk RF, Stenestrand U, Sheehan M, Haskell WL: Training effects of long versus short bouts of exercise in healthy subjects. *The American Journal of Cardiology.* 1990, *65:*1010–1013.
25. Coleman KJ, Raynor HR, Mueller DM, et al.: Providing sedentary adults with choices for meeting their walking goals. *Preventive Medicine.* 1999, *28:*510–519.
26. Woolf-May K, Kearney EM, Jones DW, et al.: The effect of two different 18-week walking programmes on aerobic fitness, selected blood lipids and factor XIIa. *Journal of Sports Sciences.* 1998, *16:*701–710.
27. Woolf-May K, Kearney EM, Owen A, et al.: The efficacy of accumulated short bouts versus single daily bouts of brisk walking in improving aerobic fitness and blood lipid profiles. *Health Educ. Res.* 1999, *14:*803–815.
28. Osei-Tutu KB, Campagna PD: The effects of short- vs. long-bout exercise on mood, VO2max., and percent body fat. *Preventive Medicine.* 2005, *40:*92–98.
29. Quinn TJ, Klooster JR, Kenefick RW: Two short, daily activity bouts vs. one long bout: Are health and fitness improvements similar over twelve and twenty-four weeks? *Journal Of Strength And Conditioning Research/National Strength & Conditioning Association.* 2006, *20:*130–135.
30. Murphy M, Nevill A, Neville C, Biddle S, Hardman A: Accumulating brisk walking for fitness, cardiovascular risk, and psychological health. *Medicine And Science In Sports And Exercise.* 2002, *34:*1468–1474.
31. Murtagh EM, Boreham CAG, Nevill A, Hare LG, Murphy MH: The effects of 60 minutes of brisk walking per week, accumulated in two different patterns, on cardiovascular risk. *Preventive Medicine.* 2005, *41:*92–97.
32. Donnelly J, Jacobsen DJ, Heelan KS, Seip R, Smith S: The effects of 18 months of intermittent vs. continuous exercise on aerobic capacity, body weight and composition, and metabolic fitness in previously sedentary, moderately obese females. *Int J Obes Relat Metab Disord.* 2000, *24:*566–572.