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# FLUID CONSUMPTION DURING CYCLING AS AFFECTED BY ROLE MODELING

A Thesis

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## ABSTRACT

Fluid loss is an inevitable part of prolonged exercise. Psychophysiological stimuli for maintaining water balance are not adequate for immediate fluid replacement. Excess fluid loss may result in detriments to health and performance.

In the present study, observational learning techniques were examined as a way of stimulating fluid replacement. Subjects cycled for 60 min under two modeling conditions: one with a model who drank water heavily (approximately 100 ml every 10 min) and one with the same model who did not drink at all. The influence of the model was found to significantly ($p < .01$) increase fluid consumption of the subjects. While cycling with the model who drank heavily, subjects consumed an average of 258.7 ml. While cycling with the model who did not drink at all, subjects consumed an average of 161.6 ml.

The results are discussed in terms of the potential social influence on fluid consumption during cycling events such as long distance touring and century rides.

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# CHAPTER I

# INTRODUCTION

## Background

In recent years cycling has become an increasingly popular activity with the number of cyclists reaching an all-time high. The U.S. Cycling Federation estimates that over 82 million Americans ride a bike recreationally and over 24,000 more are licensed competitors. The Grape-Nuts Festival alone has attracted over 40,000 riders in its first two years ("Bicycling," 1987, p. 26; "Triathlete," 1987, p. 120).

In riding for fitness, competition, or recreation, durations of an hour or longer are common. As in most prolonged activities, the body loses fluid through sweating and respiration. Fluid replacement thus becomes an important factor in maintaining homeostasis and achieving optimal performance. Fluid replacement has been shown to be of a significant value in events lasting more than 50-60 minutes (Costill, 1977). The body's primary stimulus for fluid replacement is the thirst mechanism. The thirst mechanism, which is initiated by dry mouth, serum sodium concentration and blood volume, has been found to be insufficient for fluid replacement during and immediately following exercise (Costill and Miller, 1980). Furthermore, fluid losses have been shown to be as high as 15% of body weight in long distance events with replacement of fluid during the activity seldom reaching more than 50% of this loss (Costill, 1977).

Replacing fluid that is lost during exercise may need to be stimulated by other means. One such technique with potential to influence fluid replacement is observational learning, the process through which the behavior of one person (observer) changes as a function of merely being exposed to the behavior of another person (model) (Liebert and Spiegler, 1982). Role modeling has been shown to be an effective means of influencing drinking behavior in terms of total amount of fluid consumed (Caudill and Marlatt, 1975; Caudill and Lipscomb, 1980). Naive observers altered their drinking behavior in the direction of trained models. Applying similar principles to cycling, it might be predicted that the drinking behavior of one cyclist could influence that of another cyclist.

## Purpose

The purpose of this study was to determine the influence of a model's fluid replacement behavior of an observer-partner during cycling.

## Hypothesis

It was hypothesized that the fluid consumption of subjects co-acting with a high consumption model would be significantly greater than that of subjects co-acting with a low consumption model.

## Operational Definitions

Co-active -- two individuals working independently at the same time on the same task, cycling.

High consumption model -- a confederate who drinks at a rate of 100 ml every 10 minutes (replacement guidelines from Bergstrom and Hultman, 1972, and Costill, 1977).

Low consumption model -- a confederate who does not drink at all.

Model -- a trained confederate who is aware of the experimental procedures.

## Assumptions

Subjects were not aware of the true nature of the study.

The interaction of drinking and cycling did not interfere with fluid consumption behavior.

Individual fluctuations of fitness and diet between conditions did not compromise the results.

## Limitations

An activity usually done outdoors was performed indoors; windtrainers were used.

Individual hydration levels were not precisely determined.

Volunteers were used.

Fitness levels, which may influence fluid loss, were not assessed.

In light of these limitations a word of explanation is indicated. In regards to individual hydration and fitness levels, a review of literature fails to show any studies setting standards on these measures as influencing fluid consumption during exercise. Further, the literature also suggests that regardless of these measures being identified, social influence on drinking behavior still exists.

## Delimitations

Cycling is the only mode of activity that was studied.

## Importance of the Study

It has been demonstrated that various levels of exercise-induced dehydration cause or are related to numerous detriments to performance and health (e.g., impaired thermoregulatory processes, decreased muscular endurance). While fluid replacement is the primary intervention for dehydration, exercise participants often avoid such an activity. One of the factors that may influence replacement is role modeling, particularly in regard to the fact that cycling often takes place in a social or co-active environment. What implicates cycling even further for the demonstration of modeling effects on fluid replacement is that water is normally carried on a bicycle, that wind increases sweat evaporation rates and substantial fluid loss may occur without the cyclist being aware of it.

Given this, the results of this study should be of importance to those involved in cycling at various levels; coaches, competitors, directors, commuters and tourists.

## Review of Literature

The following review consists of two parts; the first pertaining to factors relating to fluid loss and replacement and the second pertaining to studies showing the effects of modeling on drinking behavior.

Fluid loss and health and performance consequences. In a classic study, Pitts (1944) found that soldiers who were allowed to drink ad

libitum during rest periods from treadmill exercise did not maintain water balance. When compared to soldiers who maintained water balance, soldiers who did not maintain water balance had rectal temperatures that were higher and approached what Pitts called the zone of impending exhaustion.

In a study on runners, Bergstrom and Hultman (1972) found that while only 800 ml of fluid per hour can be emptied by the stomach during activity, losses may amount to 2-3 times that. A two liter loss of fluid in a 150 lb person amounts to a 3% weight reduction. Water losses of only 2% of body weight impair the body's ability to regulate heat (Gisolfi and Copping, 1974) while water losses exceeding 3% are correlated with linear increases in rectal temperature (Wyndham, 1982). In marathon events, losses of 12-15% may be evident (Costill, 1977). Losses this high are associated with a 22% reduction in plasma volume, circulatory insufficiency and failing renal function (Greenleaf, 1982).

Fluid loss has been implicated in a variety of other problems which are detrimental to both health and performance. These include decreased muscular endurance and strength, reduced aerobic endurance, slower running speeds, increased resting HR, decreased blood and plasma volumes, reduced renal blood flow and filtration fractions, increased electrolyte loss, increased risk of muscle spasms, impaired thermoregulatory processes and certain cerebrovascular disorders (Fink, 1982; Greenleaf, 1982; Houston, 1981; Tipton, 1975, 1976, 1982).

Role modeling and fluid consumption. Bandura (1977, p. 528) has stated that

> Most of the behaviors that people display are learned, either deliberately or inadvertently, through the influence of example . . . Under most circumstances, a good example is therefore a much better teacher than the consequences of unguided actions.

In regard to drinking behavior, role modeling has been demonstrated to work with repeated success. In a two-part study using taste testing and taste discrimination, three male alcoholics were paired with confederates who alternated light and heavy consumption of alcohol in 15 min blocks over two distinct one hr periods. In both parts naive subjects increased or decreased the number of sips taken and total fluid consumed resembling that of the confederates. Subjects in the taste testing experiment consumed an average 50%, 34% and 37% more alcohol in the heavy condition than in the light condition. Similar results were obtained in the taste discrimination setting (Caudill and Lipscomb, 1980).

Caudill and Marlatt (1975) used a taste rating task to measure alcohol consumption of heavy drinkers who either drank alone or in the presence of light or high consumption models. The rating sessions lasted 15 min and six male subjects were randomly assigned to each of the three conditions. Subjects who were paired with high consumption models took more and larger sips, consuming more alcohol than the subjects in the light model condition ($p < .001$) and the no-model control condition ($p < .001$).

In regards to drinking rate, role modeling has also been reported to influence subjects drinking behavior. In a natural bar setting, DeRicco and Niemann (1980) paired one female subject with four models who between returns to the subject's baseline drinking rate, modeled 4

separate rates of drinking that were 50% less than the baseline rate. In the first modeling bout, only one model exhibited the 50% slower rate. In the second bout, two models exhibited the 50% slower rate. The pattern continued until three and then four models were drinking at a rate 50% slower than the baseline rate. While differences in consumption between baseline and the first three modeling conditions were absent, the condition of four models exhibiting a 50% slower rate had the effect of decreasing the subject's baseline rate by approximately 50%.

Similar results have been reported in other studies in regards to drinking rate (DeRicco and Garlington, 1977) and total consumption (Cooper et al., 1978; Reid, 1978).

These studies demonstrate clearly that fluid consumption is susceptible to change by social influence.

Summary

In prolonged activity, fluid loss occurs and replacement is important in maintaining homeostasis. The primary stimulus for fluid replacement is the thirst mechanism, which is inadequate to stimulate total replacement of what is lost during and immediately after exercise. Numerous health and performance detriments are related to or caused by fluid loss. Fluid consumption has been shown to be influenced by role modeling.

# CHAPTER II

## METHODOLOGY AND RESULTS

### Subjects

Subjects were six male and two female volunteers from the Department of Physical Education and Dance at the University of Tennessee. The mean age of the subjects was 23.75 yrs., S.D. ± 8.9, range 20-30 and the mean weight was 154 lbs, S.D. ± 21.5, range 109-178.5. The subjects represented a variety of cycling ability and experience as determined through personal discussion. Weekly mileage ranged from under 10 to over 100.

### Materials Used

Three windtrainers (stationary stands on which the rear wheel of the bicycle rests on rollers that simulate road resistance), three 250 ml graduated cylinders, extra water bottles, bicycle tools appropriate for maintenance and adjustment.

### Procedures

Subjects rode a total of three times. The first ride was to acquaint them with the windtrainer and to determine a cadence and gear ratio to be replicated during the two test rides. The duration of the first ride was 45-60 minutes. Subjects personally chose a cadence and gear ratio that was comfortable for them. The rationale for not imposing a common physiological work rate was to increase similarity to outdoor cycling, to allow for more social interaction with the model

and to decrease the reactive effects of the experimental design. These methods would seemingly increase external validity without sacrificing internal validity.

The following two rides were test rides and subjects cycled with a model who displayed either high or low consumption. Three windtrainers were placed 2-3 feet apart and 6-8 inches ahead of the windtrainer immediately to the left. This position allowed for a common riding style and also allowed for two subjects to be tested simultaneously as the model's position obstructed the subjects' views of one another.

A within-subjects design was used and all subjects received both modeling conditions. The order of high and low conditions was counterbalanced across subjects. Two confederates acted as models; half of the subjects were paired with each model. Subjects always cycled with the same model.

Immediately before cycling, subjects reported nude weight to the nearest quarter pound. After mounting their bicycles, refrigerated water bottles containing 560 ml of water were given to all the riders. Subjects were then read the following paragraph:

> You are about to ride for 60 min at a cadence and gear ratio you have determined in your pre-test ride. For your comfort water has been provided and you are encouraged to drink as frequently as you'd like. Please feel free to interact with the cyclist next to you as it will help to pass the time. Do you have any questions? . . . Please begin.

A fan was then turned on to simulate a cross-headwind.

In the high consumption model condition the model drank immediately before beginning the ride and approximately every 10 minutes during the ride for a total of seven drinking bouts. In the low consumption model condition, the model consumed no fluid. During

the ride, the experimenter positioned himself out of view of the cyclists. Cadences were checked every ten minutes to assure consistency. Each instance a subject drank, the time of drinking was recorded to the nearest 30 seconds.

Immediately after 60 minutes, subjects dried off and nude weight was again recorded. The amount of fluid remaining in the bottles was measured in the graduated cylinders and subtracted from 560 ml to determine fluid consumed.

The second ride of the test rides was done after at least one day of rest with the opposite modeling condition that the subject experienced in the first test ride. Between rides, subjects' bicycles were checked with a tire pressure gauge and cone wrenches to keep rolling resistance comparable between conditions. Subjects always used the same windtrainer and positioning on the trainer was kept as consistent as possible between conditions.

A one-tailed correlated dependent t-test was used to test for the reliability of differences between subjects' fluid consumption in the two modeling conditions.

## Results

Of eight subjects, seven drank in the high consumption condition. All seven who drank in the high consumption model condition (HC) drank more than in the low consumption condition (LC). Total fluid consumption in the HC was 2070 ml and 1293 ml in the LC. Means were 258.7 ml and 161.6 ml, and standard deviations were 173.3 ml and 126.4 ml, respectively ($t = -2.84$, $p < .0144$). Number of drinking bouts was 23 in both conditions. Six out of seven subjects drank earlier in the

60 min of the HC than in the LC and nearly half (11/23) of the drinking bouts in the HC came within 1.5 minutes of the model's scheduled drinking. The difference in weight loss between conditions was small; subjects lost 1.47 lbs in the LC treatment and 1.28 lbs in the HC (see Table 1 for raw data).

## Discussion

The results of this study indicated that the model's drinking behavior had a significant influence on the drinking behavior of the coactive subjects. During the HC treatment subjects replaced 60% more fluid than in the LC treatment. This result is similar to that obtained by Caudill and Lipscomb (1980) who reported an average 61.5% difference in consumption means over a one hour period for two distinct experiments. The magnitude of the percentage is less though than the percent differences found by Caudill and Marlatt (1975), 160%; and DeRicco and Niemann (1980), 100%. This may, in part, be due to differences in social environment and the fewer number of subjects these researchers used. Both studies used actual bars as settings where fluid is apt to be consumed more frequently merely as a function of the setting. Also due to the smaller number of subjects these studies used, six and one, respectively, the results may not represent those of a larger sample. The settings also allowed for more social interaction and presumably then for the potential of more observational learning to occur.

The results in terms of total fluid consumed should be further discussed, however. The statistical significance of the fluid consumed between conditions may be attributed to only four of the subjects.

Table 1. Raw Data

| Subject | RPM | Speed (MPH) | Condition | Weight lbs. in - out | Time of Consumptions | Consumption ml | Wt. loss lbs. |
|---|---|---|---|---|---|---|---|
| A | 76 | 18.8 | H | 167 3/4 - 166 | 3:00, 11:30, 26:00, 35:00, 50:00 | 318 | 1.75 |
| | | | L | 168 - 166 1/2 | 9:00, 14:00, 20:30, 35:30, 41:00, 49:00, 58:30 | 300 | 1.5 |
| B | 74 | 13.9 | H | 142 1/2 - 141 1/4 | --- | 0 | 1.25 |
| | | | L | 142 - 140 1/2 | --- | 0 | 1.5 |
| C | 76 | 12.2 | L | 109 - 108 3/4 | --- | 0 | .25 |
| | | | H | 110 - 109 3/4 | 10:30, 23:30, 54 | 102 | .25 |
| D | 96 | 19 | L | 166 - 165 | 20:00, 30:30, 48:00 | 278 | 1 |
| | | | H | 166 - 165 | 19:00, 30:30, 41:00, 48:30 | 292 | 1 |
| E | 82 | 18 | H | 175 1/2 - 173 | 24:00, 45:00, 60:00 | 388 | 2.5 |
| | | | L | 178 1/2 - 175 | 26:00, 35:00, 54:00 | 168 | 3.5 |
| F | 88 | 18.4 | H | 170 1/2 - 169 1/4 | 29:30, 40:00, 48:00 | 130 | 1.5 |
| | | | L | 170 - 168 | 30:00, 45:30, 59:00 | 105 | 2 |
| G | 76 | 14.3 | L | 137 - 137 | 33:00, 49:00 | 312 | 0 |
| | | | H | 135 - 135 | 30:30, 41:30 | 540 | 0 |
| H | 74 | 14.7 | L | 163 - 161 1/2 | 6:00, 20:00, 35:00, 45:30, 54:30 | 130 | 1.5 |
| | | | H | 164 1/2 - 162 1/2 | 21:00, 37:00, 51:30 | 300 | 2.0 |
| $\bar{X}$ = | 80.3 | 16.2 | - | 154 | --- | H-258.7<br>L-161.6<br>T= -2.84<br>p<.0144 | H-1.28<br>L-1.47<br>$\bar{x}$ = 1.34 |

*wt loss = Total wt loss - fluid consumed

Subjects A, B, D and F combined to produce a total consumption difference of 57 ml, while subjects C, E, G and H combined to produce a total consumption difference of 720 ml. Given the small sample size one may then question the strength of the models' influence on drinking behavior and a possible false rejection of the null hypothesis.

However, the significance of the results is strengthened by other modeling effects which may be independent of total fluid consumption. Although frequency of drinking bouts was equal in both modeling conditions, 8 out of 23 subject drinking bouts in the HC fell within 1 minutes of the model's scheduled drinking bout. Three out of those 8 actually came during the model's drinking. An additional 3 drinking bouts came within the next 30 seconds making a total of 11 out of 23 subject drinking bouts occurring within 1.5 minutes of the model's scheduled drinking bout.

Further support of modeling influence is gained by the fact that of seven subjects who drank in the HC, six drank earlier in the 60 min ride than in the LC. Since common advice for fluid replacement is to drink before thirst occurs, it was interesting to see that the model's influence in the present study prompted the subjects to drink earlier.

The absence of any difference in drinking frequency may be explained by the small number of drinking bouts (7) exhibited by the HC models. DeRicco and Niemann (1980) presented consumption every five minutes. Caudill and Marlatt (1975) and Caudill and Lipscomb (1980) had models drinking as frequently as 80 times per hour. While further drinking bouts by the model may have increased the subject's frequency

of drinking, it would have represented an inappropriate behavior of cyclists who rarely drink more than every 10 minutes. The fact remains, however, that the potential to stimulate higher fluid consumption during exercise is substantial through social influence.

Upon analyzing the consumption results specific to this study, it is difficult to see how they could be influential in preventing injury or performance detriments. Using a typical sweat rate (1.8 lbs) and the fluid consumption means as determined in the modeling conditions, the differences in body weight loss between conditions would amount to only .4% even after a 3 hr bout of cycling. However, the practical importance of the results may be misleading when applied specifically to the conditions of the study since the mean fluid intake of both conditions was only 210 ml.

In order to highlight the potential practical importance of the results it is necessary to speculate the existence of other conditions which are common in cycling. Given a fluid intake of 500 ml/hr in a prolonged bout of cycling lasting six hours, the contribution of a 60% increase in consumption becomes more evident. Given the same 1.8 lbs/hr sweat rate and a 60% higher consumption resulting in a replacement of 800 ml/hr, a six hour ride would end in only a .16% weight loss. The baseline intake of 500 ml/hr would result in a 2.7% weight loss which is at least associated with impaired thermoregulatory processes. The resultant difference in weight loss between the conditions may become even more pronounced as the environmental factors of wind and heat are encountered, as intensity increases or if

exercise takes place over many days. All of these conditions are common to century riders, road racers and long distance tourists.

One might ask then if it is possible to apply the principles of observational learning to promote a higher level of fluid consumption. Caudill and Marlatt's (1975) high consumption mean was 43% higher than that of the present study and the difference they reported in fluid consumption between heavy and light consumption conditions was over 160%. Caudill and Lipscomb (1980) demonstrated a 74% difference between their reported high and low model consumption means with a mean high consumption condition intake that was 50% higher. Evidence suggests then that higher fluid consumption may be achieved by social influence.

There are numerous applications of the present findings to cycling situations. For instance, in road races or organized century rides, people could be stationed en route and simply drink. Another application would be to include models in activities whose purpose it would be to model appropriate fluid intake. The inclusion of more watering areas and exchanging of bottles in events may result in observational influence. Tour leaders could initiate group drink sessions before beginning cycling and whenever indicated, model appropriate replacement behavior.

## Summary

Based on the fact that average fluid replacement was only 25.6% of what subjects lost, the thirst mechanism did not supply an adequate stimulus for total fluid replacement. Role modeling increased the

subjects' consumption 60% between conditions. Due to the small mean fluid consumption, a 60% fluid consumption increase is not practical in preventing health or performance detriments. However, if a 60% potential increase is applied to a higher fluid consumption, then a substantial difference in weight loss may occur. Problems associated with exercise weight loss such as heat injury or illness may be lessened or prevented.

## Conclusions

While cycling at a comfortable speed, a person modeling ideal fluid replacement provides a social influence that is effective in stimulating the drinking behavior of an observer/partner.

## Recommendations

The potential for further study in this area is varied. Within a similar experimental design it would be interesting to study the modeling effects on fluid consumption during a variety of cycling cadences or speeds; while controlling for cycling experience or in relation to determined physiological standards. Perhaps the most practical recommendation would be to carry the design out on the road in a setting that actually exists in cycling events.

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His educational and career goals include a combination of exercise physiology and sport psychology with particular interests in weight loss and exercise and eating disorders/behaviors. His personal and moral activities involve nature and mankind's destructive abuse of animals and the environment. He has travelled extensively in Europe and America by a variety of means and spend summers leading high school students on cycling and camping trips.