THE EFFECT OF IBUPROFEN ON MEASUREMENT OF MAXIMAL VOLUNTARY STRENGTH

By

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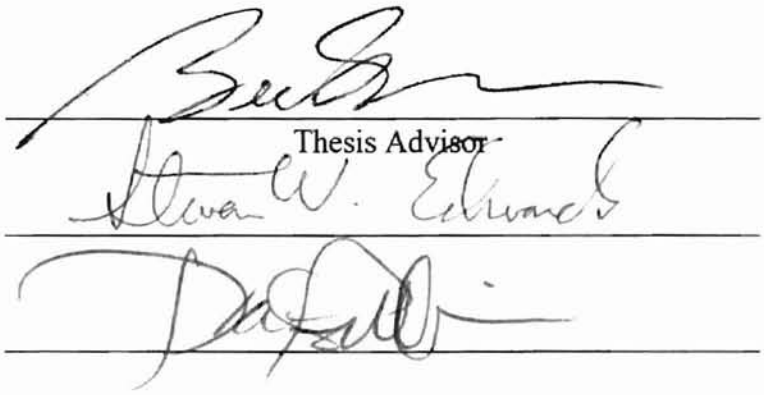

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CHAPTER I

INTRODUCTION TO THE PROBLEM

As the fitness craze takes the world by storm, people have come to realize that muscle fatigue and soreness are common with progressive resistance exercise (PRE). Many pharmaceutical companies have inferred that their drugs will relieve muscular discomfort associated with exercise. One such drug is ibuprofen, (2-((4-isobutylphenyl) propionic acid). This drug is a non-steroidal anti-inflammatory drug (NSAID), which is also an analgesic and an antipyretic (Geisslinger and Dietzel, 1989). Claims, through advertisements, suggest not only an analgesic effect, but also contend the drug may help maintain regular training frequencies and intensities otherwise hindered by muscular soreness and fatigue.

In the past, there was concern that the use of NSAIDs with acute injuries or muscular discomfort would interfere with the healing process. However, a recent meta-analysis concluded that ibuprofen does not significantly delay healing and has modest benefits over placebos for pain and soreness relief (Baumert, 1995; Forster, Magerl and Beck, 1992). Ibuprofen relieves discomfort through the inhibition of prostaglandin production (Nelson, Henderson, and Almekinders, 1993; Papazin, 1995), the prevention of neutrophil activation, and stabilization of cellular lysosomal enzymes

(Cox, Gall, and Forbes, 1991). Surgical knee studies have shown that ibuprofen used preoperatively and postoperatively lowers pain scores and aids in the rehabilitation process (Forster et al., 1992; Nelson et al., 1993). Ingested ibuprofen takes 0.5 to 1.5 hours to reach the maximum concentration in the body's plasma. Ibuprofen's efficacy is four to six hours (Baumert, 1995; Walker, Knihinicki, and Seideman, 1993). Food ingestion with ibuprofen has not shown to significantly ($p>0.05$) increase the length of time for maximal plasma concentration (Levine and Walker, 1992).

Anecdotal evidence exists suggesting that ibuprofen may positively affect maximal strength output, presumably through an analgesic effect on the skeletal muscle and joints. However, no current studies have investigated the effect of ibuprofen on maximal voluntary strength. As the public continues searching for ergogenic aids to enhance their physical performance, the use of ibuprofen may be the answer for the day-to-day discomfort associated with PRE.

Statement of the Problem

The problem of this study was to ascertain the effect of ibuprofen ingestion on measured maximal voluntary strength output. The maximal voluntary strength output was measured at three levels of isokinetic knee extension contractions.

Hypotheses

The specific hypotheses were tested to analyze the effect of ibuprofen ingestion upon maximal peak torque and muscle endurance through isokinetic testing. The study attempted to determine if the use of ibuprofen affects skeletal muscle maximum strength output. The following hypotheses were tested at $p>0.05$:

HO1: There will be no significant difference between the placebo and ibuprofen groups in the knee extension peak torque at an angular velocity of 60 degrees per second.

HO2: There will be no significant difference between the placebo and ibuprofen groups in the knee extension peak torque at an angular velocity of 180 degrees per second.

HO3: There will be no significant difference between the placebo and ibuprofen groups in the knee extension peak torque at an angular velocity of 300 degrees per second.

HO4: There will be no significant difference between the placebo and ibuprofen groups in the knee extension endurance torque between the first three repetitions and the last three repetitions at an angular velocity of 300 degrees per second (Jacobson and Weber, 1992).

Delimitations

The study was delimited by the following:

1) The total number of subjects volunteering for the study was 17.

2) Testing was conducted on a Cybex II dynamometer with a Cybex data reduction computer located in the Oklahoma State University Athletic Training Room.

3) There was one administration of 400 mg of ibuprofen to the subjects.

4) All subjects were highly trained athletes with greater than three years of resistance training experience.

5) All subjects have no past history of medical difficulties with ibuprofen ingestion.

6) All subjects were tested on their right leg.

Limitations

The study was limited by the following:

1) All subjects were required not to ingest ibuprofen for two weeks (14 days) prior to testing.

2) All subjects were required not to resistance train the quadriceps muscle group 48 hours prior to each of three tests.

3) All subjects were required to produce a maximal effort at each of the three levels of isokinetic knee extension testing.

4) All subjects were to eat similar types and amounts of food prior to 400 mg of ibuprofen or a placebo administration.

Assumptions

For the purposes of this study, the following assumptions were accepted by the researcher:

1) Subjects gave a maximal effort on each repetition for each of the three levels.

2) Subjects were not informed if 400 mg of ibuprofen or a placebo was ingested.

3) Subjects returned 90 minutes after ingesting 400 mg of ibuprofen or a placebo for testing.

4) Subjects abstained from quadriceps muscle group exercise for 48 hours prior to each testing session.

Definitions

The following terms are used in this study:

Computerized Isokinetic Testing Device = The machine that allows movement through a set arc range of 90 degrees of knee flexion to 180 degrees of knee extension at a set degree per second angular velocity.

Peak Torque = The highest value measured in foot per pounds by the computer as the arm of isokinetic machine moves through the set arc range and set angular velocity.

NSAIDs = Non-Steroidal Anti-inflammatory Drugs

IB = Ibuprofen, a non-steroidal anti-inflammatory drug that is the generic name of Advil (Wyeth-Ayerst Pharmaceuticals).

Over-the-counter dosage = The amount of milligrams per pill or capsule that the Federal Drug Administration allows to be sold without a prescription.

FDA = Federal Drug Administration is the government organization that controls all facets of prescription and nonprescription drug use and availability.

Half-life = The length of time before a drug or chemical breaks down to half its chemical properties in the nucleus.

Analgesic Effect = The anesthetizing of skeletal muscles by the drug ibuprofen.

PRE = Progressive Resistance Exercise with regard to weight lifting.

F3 = Mean of the first three repetitions at 300 degrees per second

L3 = Mean of the last three repetitions at 300 degrees per second

ROM = Range of Motion

ER = Endurance Ratio (L3/F3)

R(-) Enantiomer = The negative isomer ibuprofen becomes at the half-life of the chemical breakdown and is unusable to the body.

S(+) Enantiomer = The positive isomer ibuprofen becomes at the half-life of the chemical breakdown and is the isomer that carries the analgesic properties.

Albumin = A protein that accepts the ibuprofen, S(+) enantiomer, into the joint.

Hypokalemia = Extremely low levels of potassium in the blood manifested by episodes of weakness or paralysis, tetany and postural hypotension.

Villus Hypotrophy = The reduction of multiple, minute projections of the intestinal mucosa in the lumen of the small intestines.

Ulcer = A sore or a lesion that forms in the lining of the stomach or duodenum where pepsin and acid are present.

Duodenum = The upper 1/3 of the small intestinal tract.

Helicobacter pylori = The bacteria that destroy the mucosal lining of the stomach increasing the possibility of an ulcer formation.

Strictures = A narrowing or constriction of the lumen tube, duct or hollow organ such as the esophagus, ureter, or urethra.

Perforations = A small hole or fissure in the lining of the stomach or duodenum lining.

Diarrhea = Frequent passage of unformed, watery, bowel movements. It is a frequent symptom of gastrointestinal disturbances.

CHAPTER II

LITERATURE REVIEW

Introduction

Most people in today's exercise world are searching for ways to become bigger, faster, and stronger. Injury, pain or muscular discomfort, before or during a workout can interfere with one's effort to maximize exercise performance. These inconveniences send a strong message to the pharmaceutical and nutritional supplement companies. One of the most popular drugs advertised for the relief of exercise-induced muscular pain is ibuprofen. Ibuprofen has been proven to eliminate muscle soreness, but its manufacturer has claimed no ergogenic properties. These properties, along with anecdotal evidence, are the basis upon which this investigation is based. For simplification, this chapter will be divided into four sections:

1) Pharmacokinetics of Ibuprofen
2) Contraindications of Ibuprofen
3) Indications of Ibuprofen
4) Ibuprofen and Muscular Contractions

Pharmacokinetics of Ibuprofen

Ibuprofen, the generic form of Advil and Motrin, is a nonsteroidal anti-inflammatory drug (NSAID). The most rapid form of ibuprofen absorption is via oral ingestion (Schein, 1995). The onset of the anti-inflammatory and analgesic effect begins in as little as 0.5 hours and reaches a maximum plasma concentration in $1.8 \pm .45$ hours (Baumert, 1995; Walker, 1993). Additionally, in a study to investigate the absorption rate of ibuprofen, 600 milligrams (mg) of ibuprofen was ingested with and without the presence of food. The results indicated that there is not a significant ($p>0.05$) difference in the amount of time required for maximal plasma concentration of ibuprofen with or without the presence of food (Levine and Walker, 1992). Effectiveness of a single dose, 400 mg of ibuprofen, is four to six hours (Baumert, 1995). A recent study shows that 45% to 70% of a single dose is recovered in the urine 24 hours after ingestion (Schein, 1995).

Ibuprofen breaks down in the gut following oral ingestion. The propionic acid side-chain is transformed into the products hydroxyibuprofen and carboxyibuprofen in the first 10.2 to 12.2 minutes. At 27.0 to 29.4 minutes after ingestion, the drug is transformed into the plasma absorbable R(-) and S(+) enantiomers. The enantiomer R(-) is inactive in humans, but the S(+) enantiomer contains the pharmacological effects on the body, (Gesslinger and Dietzel, 1989). The S(+) enantiomer is absorbed into the blood plasma through the gut wall, (Levine and Walker, 1992). Although most of the S(+) enantiomer is absorbed in the blood stream, the majority of its action takes place in the

synovial joint; 60% of enantiomer binding occurs in the albumin of the joint (Cox et al., 1991). Permeability of blood vessels and membranes allows the S(+) enantiomer to enter the synovial joint (Rahim and Aubry, 1995; Walker, 1993), and the ibuprofen's anti-inflammatory and analgesic properties take effect.

Contraindications of Ibuprofen

Side-effects are always possible with the use of any medication. Some side-effects are predictable while others can cause unpredictable effects. In recent years, patients, physicians, and scientists have recognized that frequent and long-term ibuprofen use has led to numerous gastrointestinal disorders (Nelson and Henderson, 1993). Side-effects are not limited solely to ibuprofen, but to all NSAIDs. Common NSAID problems are: a bloated feeling, gas, heartburn, stomach pain, constipation, diarrhea, nausea, vomiting, (Matsen, 1995), small intestinal disorders, and stomach ulcers, (Kwo and Tremaine, 1995). The onset of documented gastrointestinal disorders dates from six weeks to two years prior to manifestation of symptoms.

One study reported a 30% incidence of heartburn, gastric upset or headaches with continuous NSAID use for 6 weeks, (Nelson and Henderson, 1993). In a controlled clinical trial, the percentage of patients reporting one or more gastrointestinal complaints ranged from 4% to 16% (Schein, 1995). A similar study revealed that 2% to 4% of patients taking NSAIDs for one year had adverse gastrointestinal events (Graham, 1995).

In one case, a 37-year-old woman was hospitalized for nausea, vomiting, large volume diarrhea, and hypokalemia. She reported taking 800 mg of ibuprofen three times a day over a two year period for pelvic pain (Kwo and Tramaine, 1995). These studies prompted physicians and drug companies to produce the following recommendations: "NSAIDs should not be used routinely to treat pain without other signs or symptoms of inflammation, since they are clearly associated with significant and occasionally serious, adverse side-effects," (Baumert, 1995).

Ulceration is one of the most serious side-effects of prolonged ibuprofen use, although it is not definitely known whether ibuprofen causes less peptic ulceration than aspirin. A one-year study involving 885 patients, compared ibuprofen to aspirin. Upon its conclusion, there were no reports of ibuprofen ulceration, while aspirin caused 13% ulceration ($p>.001$), (Schein, 1995). Lesion formation results when an imbalance occurs in the digestive fluids of the stomach and when the gastrointestinal tract is unable to defend itself against the harsh effects caused by stomach acid and pepsin (Medical Science Bulletin, 1995). Through the NSAID's inhibition of cyclooxgenase, 80% of gastric lesions are formed, thereby terminating prostaglandin formation and diverting the arachidonic acid metabolism to the lipoxygenase pathway (Kwo and Tremaine, 1995). This disruption of prostaglandin production allows Helicobacter pylori , (a bacteria), to decay and destroy the mucosal lining of the stomach, rendering the stomach lining susceptible to the damaging effects of acid and pepsin (Matsen, 1995; Medical Science Bulletin, 1995). NSAIDs interfere with the body's bicarbonate production which

normally neutralizes the stomach's naturally developed acids. Lack of bicarbonate can also cause stomach ulcerations, (Medical Science Bulletin, 1995),

There is a direct correlation between the concentration of NSAIDs and damage to the small intestine (Medical Science Bulletin, 1995). Common problems are strictures, ulcerations, perforations, diarrhea and villous atrophy. Patients who received NSAIDs regularly for more than 6 months have an increased level of risk (14%), for developing duodenal lesions (Kwo and Tremaine, 1995).

Indications of Ibuprofen

Ibuprofen is administered and recommended by physicians for treatment of rheumatic disorders, osteoarthritis, fever and pain. Clinical studies with patients have shown that ibuprofen reduces pain and inflammation better when compared to aspirin (Schein, 1995; Gesslinger and Dietzel, 1989). The action site for many arthritic conditions is the synovium. The S(+) enantiomer inhibits prostaglandin synthetase, thereby causing the analgesic effect in the joint, (Romero and Rhodes, 1993; Cox et al., 1991). Proper use of ibuprofen has been shown to reduce the body's naturally-forming arthritic condition, (Schein, 1995).

Ibuprofen and Muscular Contractions

Weight training and conditioning programs are designed to develop muscle mass and endurance by overloading the muscular contractions in a progressive resistance exercise format. These muscular contractions cause inflammation in and around the muscle tissue which leads to muscular discomfort or delayed onset muscle soreness (DOMS). There are two theories explaining this phenomenon, the tear theory and DOMS theory.

The tear theory suggests that during exercise muscle tears occur in the individual muscle fibers, (or sarcomere), from the concentric and especially eccentric muscular contractions, (Saxton, Clarkson and James, 1995). These tears cause the inflammation and pain in the joint. The DOMS theory suggests that the connective tissue in and around the muscle is damaged by heavy muscular contractions, and that there is also a metabolic imbalance of collagen surrounding the joint (Tuttle, 1995). Another study offers evidence that neuromuscular function is impaired by eccentric muscle contractions. It is hypothesized that the afferent receptors surrounding the skeletal muscle and connective tissue recognize the inflammation which increases the muscular spasm and pain (Saxton et al., 1995).

Documented studies indicate that ibuprofen reduces painful inflammation and diminishes the sensitivity of the afferent receptors (Tuttle, 1995; Forster and Magerl, 1992). The properties of ibuprofen have led to its wide use for DOMS. These properties suggest that ibuprofen can contribute positively to maximal voluntary strength output. If

ibuprofen can affect the afferent receptors before exercise, it is possible that muscular discomfort would not be recognized by the central nervous system. This disruption may allow more power to be produced by voluntary muscular contractions.

CHAPTER III

METHODS AND PROCEDURES

Subjects

Seventeen college age, male, varsity athletes, with consistent weight training experience (> 3 years), were solicited for this investigation. All subjects were assumed to be capable of eliciting a maximal force due to their extensive experience with progressive resistance exercise (PRE). Individually, the subjects were questioned about their physical fitness, PRE history, allergic reactions to ibuprofen, and were queried specifically about any past medical history of gastrointestinal discomfort with ibuprofen use. The subjects were also asked questions regarding their long-term use of ibuprofen or NSAIDs. An oral briefing of the testing procedures and expected demand was given to each subject. Following oral consent, the subjects agreed to sign an informed consent document (Appendix A), as approved by the Oklahoma State University International Review Board (IRB), (Appendix B).

Preliminary Procedures

Prior to the pretest, each subject was requested to adhere to the following specific guidelines: 1) The subjects were not to participate in weight training of the quadriceps muscle group 48 hours prior to each of the three tests. 2) The subjects were not to ingest any ibuprofen or NSAIDs 14 days prior to the pretest, because of a recommended washout period, (Cox et al., 1991). 3) Subjects were required to arrive 1 1/2 hours (90 minutes) before each of the two posttest sessions for the double-blind random administration of 400 mg of ibuprofen (Schein Pharmaceutical) or a placebo (lactose), as prepared by a registered pharmacist. 4) After the 90 minute absorption period as documented, the subjects were given the posttest.

Before the pretest, each subject was assigned a specific number to protect confidentiality. Testing procedures were thoroughly outlined before each of the three tests. The tester explained the instructions and defined the motivation for each subject prior to each test. Each individual was given the same instructions. Subjects were directed to exert a maximal effort/force with each repetition during each of the three levels, (60 degrees/second, 180 degrees/second, and 300 degrees/second). The room was kept quiet to minimize external interference.

Procedures

The subjects were isokinetically tested for maximal peak torque at three predetermined levels of velocity: 60 degrees/second (1.047 radians/second); 180 degrees/second (3.14 radians/second); 300 degrees/second (5.235 radians/second), (Mognoni, Narici, Sirtori, 1994), on a Cybex II dynamometer interfaced with a Cybex reduction computer. The experiment was structured utilizing isokinetic measurements because it has proven to be a reliable tool for assessing muscular strength in orthopedic and sport medicine settings, as well as providing test results which are both objective and reproducible (Wilk and Romaniello, 1994). The acceleration period that occurs during an isokinetic test affords valuable information on the neuromuscular maximal contraction, (Chin and Su, 1994). Hasson reported that high speed concentric isokinetic exercise has a significant impact on improving muscular torque production without deficits from DOMS, (Weber and Servedio, 1994).

To ensure validity and reliability of the Cybex II isokinetic dynamometer, the following variables were controlled during testing of each subject, (Ford, Bailey, Babich and Worrell, 1994).

1) Fixed velocity of the Cybex II isokinetic dynamometer.
2) Body position with hip flexion and knee flexion standardized.
3) Contraction mode of the Cybex II was set in a fixed mode.
4) The gravity effect torque was standardized.

The movement speed of the lever arm was set at a fixed speed (i.e. 60 degrees/second), and was used as the standard for all subjects. Even though strength output may vary from subject to subject, the fixed velocity of the Cybex II isokinetic device remains identical (Jacobson, Weber, Claypool and Hunt, 1992). The hips of each subject were flexed at 110 degrees with knee flexion established at 90 degrees. This hip and knee combination has been shown to create the best maximal peak torque during quadriceps muscle group testing, (Ford et al., 1994). The contraction mode on the Cybex II was set for concentric muscle contraction as this is the common form of measurement for maximal peak torque. Lastly, the gravity effect torque was standardized by placing the axis of the Cybex II arm at the axis of the knee, and the lower leg pad 2.5 inches superior to the medial malleolus (Chin and Su, 1994; Ford et al.). Subjects' positions were stabilized by placement of four velcro straps, binding the trunk, waist, hip, and lower leg, while still allowing for full knee extension, since body movement has been shown to interfere with the isokinetic values (Greenberger and Paterno, 1995; Magnoni et al., 1994).

Once the subjects were properly situated, the test began with two practice contractions each at 25% of maximal contraction at each velocity level. These practice contractions allowed the subject to realize the amount of force and speed that would be expected during testing. The tests consisted of six repetitions at 60 degrees/second, followed by six repetitions at 180 degrees/second and finally fifteen repetitions at 300 degrees/second. A two minute (120 seconds) rest period was given between each trial to

minimize fatigue (Wilk and Ramanello, 1994). Total testing time was approximately 15 minutes.

Following the pretest on Monday, subjects were reminded to return 90 minutes prior to their posttest on the next Wednesday. The following Friday, the subjects would likewise return 90 minutes prior to the posttest. The 90 minute reappearance was to give the subjects the ibuprofen or placebo for the required absorption period. All tests were completed 48 hours apart. The experimental procedures were identical for all tests.

The four variables that were measured during each isokinetic test were:

1) Maximal peak torque at 30 degrees/second or 1.047 radians/second

2) Maximal peak torque at 180 degrees/second or 3.14 radians/second

3) Maximal peak torque at 300 degrees/second or 5.235 radians/second

4) Endurance ratio at 300 degrees/second or 5.235 radians/second

The data was calculated in foot/pounds and appear in Appendix C.

Data Analysis

A paired t-test of means was used to compare 400 mg of ibuprofen and the placebo group means for each of the dependent variables. The endurance ratio was calculated by dividing the mean of the last three repetitions by the mean of the first three repetitions at 300 degrees/second. The alpha level was set at $p>0.05$.

CHAPTER IV

RESULTS AND DISCUSSION

Characteristics of Subjects

Seventeen athletes participated in this investigation. One additional subject was removed from the study, as he sustained a back injury while participating in an offseason weight training and conditioning program. All subjects were pretested on a Monday. On the following Wednesday, the random, double-blind administration of 400 mg of ibuprofen or a placebo was issued to the 16 participants remaining in the study. After a 90 minute absorption period, the subjects were tested again with the identical protocol used for the pretest. On the following Friday, the other half of the double-blind study was administered to the subjects. Once again, the same testing protocol was used on the third day of testing. All subjects were in an offseason weight training program or currently in season at the time of testing. Testing was completed during the same week for sixteen subjects. The raw score data was compiled and entered in Table I.

TABLE I
RAW SCORES MEASURED IN FOOT/POUNDS

subj	PR60	PR180	PR300	PRF3	PRL3	PRER	PL60	PL180	PL300	PLF3	PLL3	PLER	IB60	IB180	IB300	IBF3	IBL3	IBER
1	190	132	72	56	62	1.11	192	148	108	102	88	0.86	214	156	116	112.7	86	0.76
2	218	172	134	126.6	85.3	0.61	194	186	130	98	97.3	0.99	208	180	152	145.3	100.7	0.69
3	190	140	86	47.3	78.7	1.67	214	188	126	111.3	92	0.83	196	172	128	115.3	84.7	0.73
4	250	194	156	136.7	84.7	0.62	240	192	156	144.7	84.7	0.59	192	188	144	104.7	103.3	0.73
5	222	168	108	89.3	79.3	0.89	224	166	122	100	77.3	0.77	204	168	120	112	84.3	0.75
6	78	72	60	51.6	47.3	0.92	100	84	68	63.3	51.3	0.81	84	80	66	46	44.7	0.97
7	145	95	62	62	43.6	0.7	162	105	72	70	39.3	0.56	144	104	72	69.3	42.7	0.62
8	144	132	120	113.3	99.3	0.88	144	150	136	126.7	116	0.92	126	166	134	121.3	112	0.92
9	185	132	94	88.6	72	0.81	166	130	98	92.3	72.7	0.79	158	124	102	98	69.3	0.71
10	216	150	108	106.6	93.3	0.88	208	154	122	108	103.3	0.96	194	150	130	114	100.7	0.88
11	198	144	110	108.7	84	0.77	140	158	134	114	112	0.98	166	166	132	118	106	0.9
12	222	128	96	78.3	84	1.07	Subject was dropped from the experiment because of a non-related back injury.											
13	240	144	108	107.3	89.3	0.83	220	172	112	109.3	82	0.75	190	156	120	108.7	80	0.74
14	168	108	72	71.3	45.7	0.64	144	124	94	83.3	63.3	0.76	154	114	90	86	67.3	0.78
15	228	138	108	87.3	85	0.97	198	144	112	109.3	82	0.75	220	150	118	102.7	92	0.9
16	220	140	108	106.7	72	0.67	182	136	108	105	70	0.67	190	148	118	116	74.7	0.64
17	144	94	66	56	46.7	0.83	142	96	72	68	56.7	0.83	154	96	81	60.7	63.3	1.04

Results at the Angular Velocity of 60 Degrees/Second

Statistical analysis for the maximal peak touque at 60 degrees/second found no significant difference, ($p < .05$) between the ibuprofen and placebo groups (Table II). However, there was statistical significance in the pretest and ibuprofen groups. The data indicated a drop in the maximal peak torque in the ibuprofen when compared to the placebo group. There was no statistical significance between the placebo and the pretest groups. The first hypothesis was accepted as there was no significant difference between the placebo and the ibuprofen groups in the knee extension maximal peak torque at an angular velocity of 60 degrees/second. This lack of increase/decrease in maximal peak torque rejected the investigator's theory, by anecdotal evidence, that ibuprofen may increase voluntary maximal strength with the use of ibuprofen.

Results at the Angular Velocity of 180 Degrees/Second

Statistical analysis for the maximal peake torque at 180 degrees/second found no significant difference, ($p < .05$) between the placebo and ibuprofen groups (Table II). However, there were significant levels of improvement in the placebo and ibuprofen groups when compared to the pretest group at this velocity. The second hypothesis was accepted as there was no significant difference between the placebo and ibuprofen groups in knee extension maximal peak torque at an angular velocity of 180 degrees/second.

The lack of difference between the placebo and ibuprofen groups indicates that the use of ibuprofen does not improve voluntary strength at 180 degrees/second.

Results at the Angular Velocity of 300 Degrees/Second

Statistical analysis for the maximal peak torque at 300 degrees/second found no significant difference, ($p < .05$) between the placebo and ibuprofen groups (Table II). However, there was significant improvement between the placebo and ibuprofen compared to the pretest group. The third hypothesis was accepted as there was no significant level of improvement between the placebo and ibuprofen groups at a maximal peak torque at the angular velocity of 300 degrees/second. The lack of improvement shows that ibuprofen results in no statistical benefit at an angular velocity of 300 degree/second.

Results of the Endurance Ratio at 300 Degrees/Second

Statistical analysis for the endurance ratio at 300 degrees/second found no significant difference, ($p < .05$) between the pretest, placebo, and ibuprofen groups (Table II). There was no significant improvement or decline in the endurance ratios. The fourth hypothesis was accepted as there were no significant differences between the placebo and ibuprofen groups in the endurance ratio at an angular velocity of 300 degrees/second.

TABLE II

Paired t-Test for

Ibuprofen -vs- Placebo

Variable	Number of cases	Mean	Standard Deviation	t value	p >.05 2-tail probability
PL 60	16	179.375	38.552	0.89	.389
IB 60		174.625	36.432		
PL 180	16	145.813	32.303	0.40	.691
IB 180		144.875	31.858		
PL 300	16	110.625	24.998	-1.70	.110
IB 300		113.938	25.173		
PL ER	16	.8012	.127	.12	.908
IB ER		.7975	.031		

PL 60 = Placebo at 60 degrees/second

IB 60 = Ibuprofen at 60 degrees/second

PL 180 = Placebo at 180 degrees/second

IB 180 = Ibuprofen at 180 degrees/second

PL 300 = Placebo at 300 degrees/second

IB 300 = Ibuprofen at 300 degrees/second

PL ER = Placebo Endurance Ratio

IB ER = Ibuprofen Endurance Ratio

Discussion of Results

The results of the present experiment demonstrated no significant difference, ($p < .05$) between the placebo and the ibuprofen groups, rejecting anecdotal evidence which may lead one to speculate that ibuprofen improves maximal voluntary strength output. Explanations concerning the lack of significance between the control and ibuprofen group can only be speculative, although the following factors may be partly responsible for the results:

1) Ibuprofen dosages were not administered according to body weight. Subjects' weight ranged from 245 to 150 pounds, hence a difference in concentration may have occurred.

2) The subjects were in a fatigued state as they were either in season or in off-season conditioning/weight training. The pretest was conducted on Monday and may have resulted in greater pretest scores as the weekend rest period seemed to be the reason Friday's posttest scores were lower.

3) The subjects had a learned response with the usage of the Cybex II Isokinetic Device.

4) The tainted nature of the subjects precluded significant muscle soreness and hence benefit from ibuprofen.

The subjects took 400 mg of ibuprofen, as is the FDA recommended over-the-counter dosage. The FDA based these dosages on the average size of adults. An athlete, in general, is different than the average adult in height, weight and body composition. The body size of these athletes may demand higher dosages of ibuprofen for the afferent

receptor response at the neuromuscular junction. The increase of ibuprofen concentration may positively affect a maximal voluntary strength output, by the inhibition of prostaglandin production.

Another explanation may have been a fatigue factor. The subjects were under a great amount of workload in their season or off-season training. This workload may have placed too great a demand on the subjects throughout the week of testing. Fatigue was very evident in the comparison between the subjects pretest on Monday and their posttest on Wednesday and Friday. The mean peak torque at 60 degrees/second in the placebo and ibuprofen groups decreased compared to the pretest group. Because the pretest group was tested on Monday, the weekend allowed them to fully regain their energy and recover strength. On Wednesday and Friday, the subjects had been through two or four days of practice, off-season running, weight training. The off-season subjects were beginning their second week of conditioning. The lack of time for the body to adjust to the training demands could have also offset this group during the two posttests. The other problem was that the subjects were required to arrive 90 minutes prior to post-testing for the drug administration. This adjustment in an athlete's schedule can be very difficult. The early arrival became a nuisance to many of the subjects which precluded a poor effort during their test.

The final possible reason for the results may have resulted from an individual learned response. Many of the subjects complained during the two posttests of the increase in difficulty at the angular velocity of 60 degrees/second. Comments said were, "This one is too hard," "I hate this level, you should have warned me on the difficulty,"

and "You made this one harder this time versus the first time." The subjects, regardless of motivation, did not seem to exert the same maximal effort at this velocity as they did at the pretest.

Additionally, many of the subjects realized after completing the pretest that 15 repetitions at 300 degrees/second is quite fatiguing. The load was not the problem: The number of repititions was the common complaint. The subjects seemed to exert a lesser force during the first few repititions so as not to struggle performing the last five repetitions. This was apparent in many of the Cybex II output sheets. The effort of the first three repetitions exhibited less foot/pounds than the middle five repetitions. The repetitive scores tapered further for the last three repititions, as the leg began to fatigue. A learned response may have drastically skewed the statistics for the endurance ratio.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to ascertain the effect of ibuprofen ingestion on measured maximal voluntary strength output. seventeen athletes participated. One subject was removed as he sustained a back injury. The subjects were isokinetically tested for knee extension at three angular velocities, (60 degrees/second, 180 degrees/second, and 300 degrees/second). All subjects were pretested on Monday. On the following Wednesday, the random, double-blind administration of 400 mg of ibuprofen or a placebo was administered to the remaining sixteen subjects. After the 90 minute absorption period, the subjects were tested again with the identical protocol used for the pretest. On the following Friday. the other half of the double-blind study was administered to the subjects. Once again, the same testing protocol was used on the third day of testing. Testing was completed during the same week for the sixteen subjects.

Findings

Statistical analyses of the investigation revealed the use of ibuprofen does not significantly increase maximal voluntary strength output. At all levels (60 degrees/second, 180 degrees/second, and 300 degrees/second), the maximal peak torque was unaffected by the oral ingestion of 400 mg of ibuprofen. The data also indicated that the endurance of maximal voluntary contractions at 300 degrees/second was not significantly affected with the administration of ibuprofen.

HO1: There is no significant difference between the placebo and ibuprofen groups in the knee extension maximal peak torque at an angular velocity of 60 degrees per second. Accepted

HO2: There is no significant difference between the placebo and ibuprofen groups in the knee extension peak maximal peak torque at an angular velocity of 180 degrees per second. Accepted

HO3: There is no significant difference between the placebo and ibuprofen groups in the knee extension maximal peak torque at an angular velocity of 300 degrees per second. Accepted

HO4: There is no significant difference between the placebo and ibuprofen groups in the knee extension endurance ratio torque between the first three and last three repetitions at an angular velocity of 300 degrees per second. Accepted

The original hypotheses were accepted as there was no significant difference, ($p < .05$) between the placebo and ibuprofen groups in any of the four variables.

Conclusion

The purpose of this study was to investigate the possibility that ibuprofen may contain ergogenic properties by increasing maximal voluntary strength output. Although this study indicated that there was no significant difference between ibuprofen or placebo use on voluntary maximal strength output in leg extension, additional research with ibuprofen is recommended as this experiment contained certain weaknesses.

Recommendations for Further Study

Although these weaknesses were only speculative, they are realistic regarding the data collected. Future investigations into the use of ibuprofen and resistant training should include all or some of the following changes:

1) Athletes should not be in season or in an off-season conditioning program and should be idle during the week of testing.

2) The ibuprofen should be administered in higher dosages accordingly, as the subjects' body weight may be a factor.

3) The use of multiple practice sessions on the isokinetic device prior to testing to eliminate a possible learned response.

The literature review and anecdotal evidence indicate too many positive responses to not continue with further studies.

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APPENDIXES

APPENDIX A

CONSENT FORM DOCUMENT

Consent Form

"I _____ hereby authorize or direct Dr. Jacobson, Dr. Edwards, Dr. Kulling and Wade Bartlett, or assistants, or associates to perform the following treatment or procedure."

Initiate a knee extension strength measurement on isokinetic machine. The subjects will perform 6 repetitions at 60 degrees/second, 6 repetitions at 180 degrees/second, 15 repetitions at 300 degrees/second. The subject will be given a 2 minute (120 second) rest period between each level of testing.

The subjects will be administered 400 mg of ibuprofen or a placebo. A double-blind randomized design will be used to administer either a placebo or ibuprofen. The subject will return to the testing site 1 1/2 hr (90 minutes) following ingestion to perform the test again using the same protocol as the pre-test.

The procedure will last approximately 15 minutes per testing session. All data will be kept confidential.

You, the subject, may experience some discomfort in your quadricep muscle group as a result of the isokinetic test, however this will not be unlike what you may have experience during a normal bout of weight training. Although highly unlikely, you may also experience some gastric discomfort from the administration of the placebo or ibuprofen, but this will not last long or cause any permanent damage. Possible benefits from this study will include, but not be limited to, rejecting or accepting the hypothesis that ibuprofen can be beneficial to maximum strength output.

This is done as part of an investigation entitled, "The effect of Ibuprofen on Measurement of Maximal Voluntary Strength."

The purpose of this investigation is to ascertain the physiological benefits, if any, of the use of ibuprofen on strength performance.

I understand that participation is voluntary, there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at anytime without penalty after notifying the project director.

I may contact Dr. Bert Jacobson at (405) 744-5500 or Wade Bartlett at (405) 744-7416. I may also contact Gay Clarkson, Executive Secretary, 305 Whitehurst, Oklahoma State University, Stillwater, Oklahoma, 74078, (405) 744-5700.

I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: _____ Time:_____ (am/pm)

Signed:_____
Signature of Subject

Witness:_____
Signature of Witness

I certify that I have personally explained all elements of this form to the subject or his representative before requesting the subject or his representative to sign it.

Signed:_____

APPENDIX B

INTERNATIONAL REVIEW BOARD APPROVAL

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 01-10-97 **IRB#: ED-97-050**

Proposal Title: THE EFFECT OF IBUPROFEN ON MAXIMAL VOLUNTARY STRENGTH

Principal Investigator(s): Bert Jacobson, Wade Bartlett

Reviewed and Processed as: Expedited

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING, AS WELL AS ARE SUBJECT TO MONITORING AT ANY TIME DURING THE APPROVAL PERIOD.
APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval are as follows:

Signature:  Date: January 15, 1997

Chair of Institutional Review Board

cc: Wade Bartlett

VITA

Wade Alan Bartlett

Candidate for the Degree of

Master of Science

Thesis: THE EFFECT OF IBUPROFEN ON MEASUREMENT OF MAXIMAL VOLUNTARY STRENGTH

Major Field: Health, Physical Education, and Leisure

Biographical:

Personal Data: Born in Eugene, Oregon, October 7, 1970, the son of Gary E. and Patricia M. Bartlett

Education: Graduated from Altoona High School, Altoona, Wisconsin, in June1989; received Bachelor of Science Degree in Physical Education with emphasis in Athletic Training from Mankato State University, Mankato, Minnesota in June 1993; completed requirements for the Master of Science Degree at Oklahoma State University in May, 1997.

Professional Experience: Head High School/Clinical Athletic Trainer, Sport and Preventive Medicine Corporation, August 1993 to June 1995; Graduate Assistant Athletic Trainer, Oklahoma State University, August 1995 to May 1997.